

VOL. 97 • NO. 13 • 1 JUL 2016

EOS

Earth & Space Science News

Career Paths
for African-American Students

Did Solar Flares
Cook Up Life?

High Energy Growth
Forecast Through 2040

VOLCANIC ERUPTIONS

AT PLATE
BOUNDARIES

Give Your Research the Visibility it Deserves

Abstract Submission Deadline: 3 August



Submit by 27 July and Win Big

Submit your abstract by 27 July for the chance to win Fall Meeting VIP status, including front row seats for two at all keynote lectures, and more

fallmeeting.agu.org

1 JULY 2016
VOLUME 97, ISSUE 13



12

COVER

Understanding Volcanic Eruptions Where Plates Meet

A new project clarifies the relationships between tectonics and volcanic systems and how they influence hazards on Italy's Mount Etna and Vulcano and Lipari islands.

PROJECT UPDATE



9

Creating Career Paths for African-American Students in Geosciences

A new initiative at Stony Brook University teaches marketable skills, engages students in research projects, and fosters professional career tracks of underrepresented minorities.

NEWS



6

Advisory Panel Calls for Large Increase for Ocean Exploration

The recently established Ocean Exploration Advisory Board also urged the National Oceanic and Atmospheric Administration to increase its role in federal coordination of exploration.

RESEARCH SPOTLIGHT

31 Researchers Attribute Human Influence on Climate Back to 1930s

A new study finds that humans likely have triggered the past 16 record-breaking hot years on Earth, up to 2014.

DEPARTMENTS



30



7

3–6 News

High Energy Growth, Fossil Fuel Dependence Forecast Through 2040; Did Solar Flares Cook Up Life on Earth?; Storms Cause Infrequent Turbulence for Aircraft, New Study Finds; Advisory Panel Calls for Large Increase for Ocean Exploration.

7–8 Meeting Reports

Extending Recent Seismic Imaging Successes to South America; Norway and Cuba Evaluate Bilateral Climate Research Results.

18–28 AGU News

How on Earth to Decide Where on Mars to Land?; Recognizing 2015 Reviewers for AGU.

30–32 Research Spotlight

Streamlining Rapid Tsunami Forecasting; Researchers Attribute Human Influence on Climate Back to 1930s; The Role of Water in Earth's Tectonic Plumbing Systems; Martian Carbonates Spotted by the Orbiter; Improving the Identification of Extreme U.S. Precipitation Trends.

33–35 Positions Available

Current job openings in the Earth and space sciences.

36 Postcards from the Field

A view of Edinburg of the Seven Seas, the main settlement on Tristan da Cunha, an island in the southern Atlantic Ocean.

On the Cover

Lava flows from Italy's Mount Etna on the island of Sicily. Credit: Getty Images/DEA/F. Barbagallo

EOS®

Editor in Chief

Barbara T. Richman: AGU, Washington, D. C., USA; eos_brichman@agu.org

Editors

Christina M. S. Cohen
California Institute
of Technology, Pasadena,
Calif., USA;
cohen@srl.caltech.edu

Wendy S. Gordon
Ecologia Consulting,
Austin, Texas, USA;
wendy@ecologiaconsulting
.com

Carol A. Stein
Department of Earth and
Environmental Sciences,
University of Illinois at
Chicago, Chicago, Ill.,
USA; cstein@uic.edu

José D. Fuentes

Department of Meteorology,
Pennsylvania State
University, University
Park, Pa., USA;
juf15@meteo.psu.edu

David Halpern

Jet Propulsion Laboratory,
Pasadena, Calif., USA;
davidhalpern29@gmail
.com

Editorial Advisory Board

M. Lee Allison, Earth and Space
Science Informatics

Mark G. Flanner, Atmospheric
Sciences

Nicola J. Fox, Space Physics
and Aeronomy

Steve Frolking, Biogeosciences

Edward J. Garnero, Study of the
Earth's Deep Interior

Michael N. Gooseff, Hydrology

Brian C. Gunter, Geodesy

Kristine C. Harper, History
of Geophysics

Susan E. Hough, Natural Hazards

Emily R. Johnson, Volcanology,
Geochemistry, and Petrology

Keith D. Koper, Seismology

Robert E. Kopp, Geomagnetism
and Paleomagnetism

John W. Lane, Near-Surface Geophysics

Jian Lin, Tectonophysics

Figen Mekik, Paleoclimatology
and Paleoclimatology

Jerry L. Miller, Ocean Sciences

Michael A. Mischna, Planetary Sciences

Thomas H. Painter, Cryosphere Sciences

Philip J. Rasch, Global Environmental
Change

Eric M. Riggs, Education

Adrian Tuck, Nonlinear Geophysics

Sergio Vinciguerra, Mineral
and Rock Physics

Andrew C. Wilcox, Earth and Planetary
Surface Processes

Earle Williams, Atmospheric
and Space Electricity

Mary Lou Zoback, Societal Impacts
and Policy Sciences

Staff

Production and Design: Faith A. Ishii, Production Manager; Melissa A. Tribur, Senior Production Specialist; Liz Castenson, Editorial and Production Coordinator; Elizabeth Jacobsen, Production Intern; Yael Fitzpatrick, Manager, Design and Branding; Valerie Bassett and Travis Frazier, Electronic Graphics Specialists

Editorial: Peter L. Weiss, Manager/Senior News Editor; Mohi Kumar, Scientific Content Editor; Randy Showstack, Senior News Writer; JoAnna Wendel, News Writer; Amy Coombs and Elizabeth Deatrick, Editorial Interns

Marketing: Angelo Bouselli, Marketing Program Manager; Jamie R. Liu, Manager, Marketing

Advertising: Christy Hanson, Manager; Tel: +1-202-777-7536; Email: advertising@agu.org

©2016. American Geophysical Union. All Rights Reserved. Material in this issue may be photocopied by individual scientists for research or classroom use. Permission is also granted to use short quotes, figures, and tables for publication in scientific books and journals. For permission for any other uses, contact the AGU Publications Office.

Eos (ISSN 0096-3941) is published semi-monthly, on the 1st and 15th of the month by the American Geophysical Union, 2000 Florida Ave., NW, Washington, DC 20009, USA. Periodical Class postage paid at Washington, D. C., and at additional mailing offices. POSTMASTER: Send address changes to Member Service Center, 2000 Florida Ave., NW, Washington, DC 20009, USA.

Member Service Center: 8:00 a.m.–6:00 p.m. Eastern time; Tel: +1-202-462-6900; Fax: +1-202-328-0566; Tel. orders in U.S.: 1-800-966-2481; Email: service@agu.org.

Use AGU's Geophysical Electronic Manuscript Submissions system to submit a manuscript: <http://eos-submit.agu.org>.

Views expressed in this publication do not necessarily reflect official positions of the American Geophysical Union unless expressly stated.

Christine W. McEntee, Executive Director/CEO

AGU
American Geophysical Union



High Energy Growth, Fossil Fuel Dependence Forecast Through 2040

The world's energy consumption will increase by 48% between 2012 and 2040, with fossil fuels accounting for more than 75% of world energy use in 2040, according to the U.S. Energy Information Administration (EIA). Fossil fuels supplied 83% of global energy demand in 2015.

Energy-related carbon dioxide (CO₂) emissions will increase 34% during that time span, with annual emissions rising from 32 billion metric tons in 2012 to 43 billion metric tons in 2040, the agency projects. Coal will continue to generate the most energy-related CO₂ emissions worldwide, although its share will decline from 43% in 2012 to 38% in 2040, according to *International Energy Outlook 2016* (IEO), an EIA report released in May at a briefing in Washington, D. C. (see <http://bit.ly/EIAREport-2016>).

Meeting Climate Targets

The numbers in the 11 May report "indicated the challenge for the world to reduce global CO₂ emissions substantially by 2040 and beyond," Jan Mares, senior policy adviser with Resources for the Future, told *Eos*. The organization is a Washington, D. C.-based think tank that focuses on natural resources and environment issues. Other energy and climate analysts said the new projections indicate that the means of energy production need to shift soon if the world is to achieve climate targets.

"The low hanging fruit, which is substituting [natural] gas for coal, seems to be on track and looks pretty robust," David Goldwyn, president of Goldwyn Global Strategies, an international energy advisory consultancy, told *Eos*. "But it's also clear that we need a big technological step change to get to 2 degrees [Celsius] or even frankly to stabilize emissions at the level we have right now. We're not there yet, and the growth in renewables, which is mostly hydro, is not going to get us there."

"A business-as-usual scenario, with no new policies beyond those that exist right now, would be disastrous from a climate perspective," Rachel Cleetus, lead economist and climate policy manager for the Union of Concerned Scientists, told *Eos*. "The good news is we are not in a business-as-usual world," she said, citing the recent Paris climate agreement (see <http://bit.ly/COP21-signed>) and commitments by major emitters to cut carbon and increase renewables and efficiency.

The EIA report includes some details from the Paris agreement but notes uncertainty about whether countries will meet their climate targets. EIA head Adam Sieminski said at the briefing that incorporating country climate pledges into the forecast "is complicated" but that the next IEO in 2017 "will probably have more to say" about those commitments.

Renewables on a Fast Track

According to the EIA, renewable energy will be the fastest growing energy source, climbing by 2.6% per year, and nuclear energy will increase from 4% to 6% of the energy pie. Coal, which the report deemed "the world's slowest growing energy source," will rise by about 0.6% per year. In 2040, coal, natural gas, and renewables each will contribute just under 30% of the world's net electricity generation, the report states.

Cleetus told *Eos* that the EIA forecast likely underestimates contributions from renewables and energy efficiency and does not address the implications of rising methane emissions associated with natural gas use. The forecast "illustrates the pitfalls of an over-reliance on natural gas as we shift away from coal," she also said.

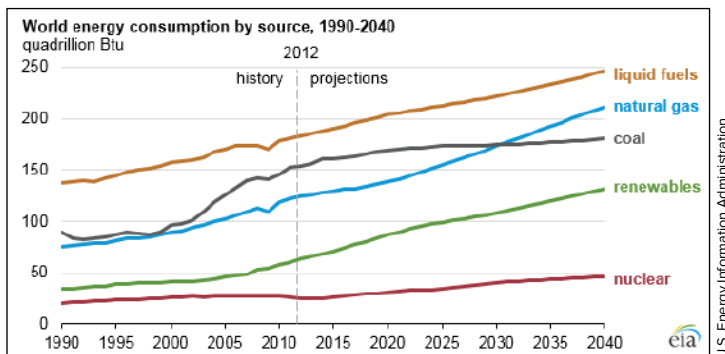
Asian Energy Consumption Continues Rapid Growth

The outlook forecasts more than half of the energy growth

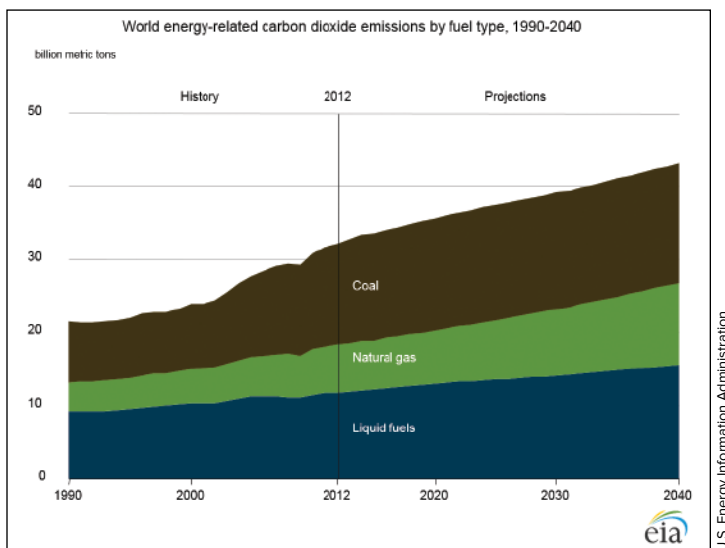
through 2040 coming from China, India, Indonesia, and other developing countries in Asia.

EIA's Sieminski said at the briefing that some global issues increase the uncertainty of the forecast, including economic growth rates in China and elsewhere, technological innovations, the future of nuclear generating capacity, the implementation and strength of climate policies, and unrest in oil-producing countries.

By **Randy Showstack**, Staff Writer



Fossil fuels continue to play a key role in meeting energy demands through 2040, according to EIA's energy outlook. Btu = British thermal unit ("1055 joules).



The energy outlook forecasts that energy-related carbon dioxide emissions will increase 34% between 2012 and 2040. This chart shows historical and projected world energy-related carbon dioxide emissions by fuel type, from 1990 through 2040, in billions of metric tons.

Did Solar Flares Cook Up Life on Earth?

Space weather today threatens our satellites, our space station, and our telecommunications, but 4 billion years ago, large solar flares and their associated energetic particles could have provided the planet its first ingredients for life.

Researchers at NASA have found that when the Sun was about half a billion years old, large solar flares—larger than any recorded by humans—could have changed the very chemistry of Earth’s atmosphere. What’s more, bombardment of the planet by high-energy particles from those jets of superhot solar plasma might have prompted organic molecules considered precursors to life to form from simpler inorganic molecules then abundant on primordial Earth.

One of the types of molecules that could have newly formed back then is a potent greenhouse gas. Thus the findings may illuminate a long-standing mystery about how Earth could have been so warm and hospitable to life at a time when, despite the solar flares, the Sun was significantly less bright than it is today.

“To make organic stuff out of inorganic stuff, you need a lot of energy,” said Vladimir Airapetian, an astrophysicist at NASA’s Goddard Space Flight Center in Greenbelt, Md. Airapetian, the lead author on a paper about the research published recently in *Nature Geoscience*, explained that perhaps that energy came from solar flares (see <http://bit.ly/super-flares-life>).

The new findings may also affect how researchers assess the prospects for life on worlds orbiting other stars by putting a new emphasis on young, active stars.

Solar Flares from Young Suns

For almost 10 years, NASA’s Kepler telescope has been closely observing stars across the galaxy and the exoplanets that orbit them. Previous observations by the telescope have revealed that stars similar to our Sun and younger than a billion years old temporarily brightened from time to time, indicating that

they released huge bursts of radiation and magnetic energy, Airapetian said. These bursts, called super flares, can be quite frequent—observers see some of these stars belching out 10 of these super flares in a day.

Using these observations, Airapetian and his team extrapolated that when our Sun was

an atmospheric model using scientists’ best estimates of concentrations of different gases in the atmosphere 4 billion years ago; at that time, molecular nitrogen (N_2) was a main component of the atmosphere, along with carbon dioxide (CO_2), methane, and water vapor. They then subjected their model atmosphere to simulated super solar flares that they suspect the young Sun produced—sometimes multiple times per day—and studied what happened to the model atmosphere.

The researchers found that energetic particles associated with super solar flares compressed Earth’s magnetic field and created huge gaps at the poles, which allowed highly energetic solar protons to pierce the atmosphere. Those protons knocked electrons around like bowling pins, which knocked into more electrons in an “avalanche of electrons,” Airapetian said. This “avalanche” ionized atoms and tore apart existing carbon dioxide, methane, and water vapor molecules, as well as molecular nitrogen—an extremely unreactive and strongly bonded molecule, Airapetian said. The resulting highly reactive substances acted as building blocks for new substances.

“Once you have those building blocks, you have a fertile environment to start reactive chemistry,” Airapetian said.

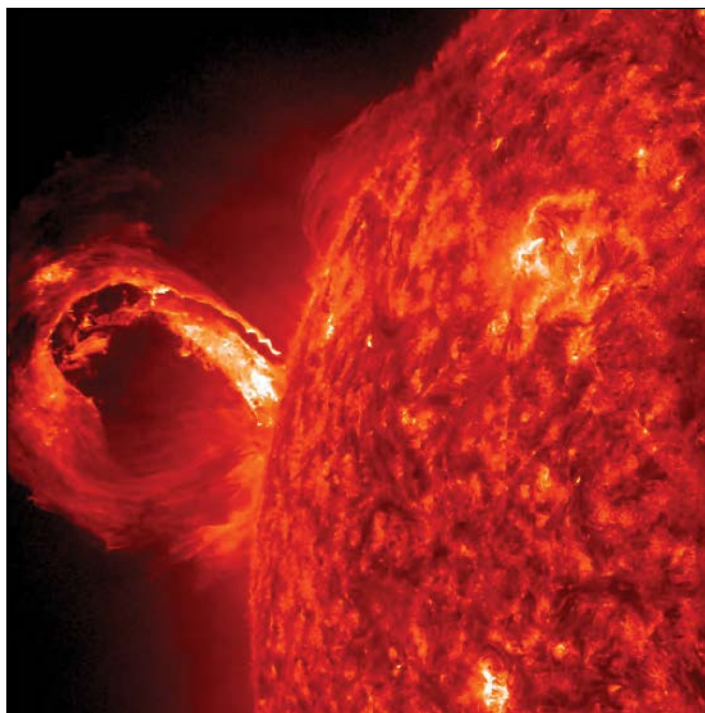
One molecule that may have formed in Earth’s infant atmosphere was hydrogen cyanide (HCN)—a molecule considered vital to life’s origins (see <http://bit.ly/origins-solution>). The newly formed HCN in a turbulent atmosphere would have dissolved into clouds and rained out, Airapetian said, likely interacting with

water to form other molecules necessary for life, like formaldehyde, amino acids, and complex sugars.

This barrage of solar flares could have been like a worldwide version of the Miller-Urey experiments, Airapetian said, when scientists sparked artificial “atmospheres,” full of gases like carbon dioxide, methane, ammonia, and water vapor, with electrical charges and found that this gave rise to amino acids, one of the building blocks of life (see <http://bit.ly/M-Uexperiment-video>).

Faint Young Sun

Another molecule that may have formed in this energized atmosphere was nitrous oxide (N_2O). You’ve probably heard this gas called



Solar flares, the largest explosions in our solar system, took place much more frequently 4 billion years ago than today, bombarding Earth with energetic protons and radiation.

about half a billion years old, it likely bombarded Earth with a constant stream of super solar flares—up to 5 times larger than the infamous Carrington event in 1859 (see <http://bit.ly/Carrington-Superstorm>). That magnetic storm, the largest ever recorded by humans, knocked out telegraph operations around the world and sent the aurora borealis streaming as far south as Miami, Fla. A similar event today would cause trillions of dollars in damage to telecommunications, Airapetian said, and throw cities around the world into catastrophic power outages.

All About Energy

To find out how these super flares may have affected infant Earth, the researchers created

laughing gas for its ability to calm even the most anxious dental patients.

However, “laughing gas is not a laughing matter for early Earth,” Airapetian said. This nitrous oxide was important for young Earth, he said.

Although the Sun persistently showered Earth in solar flares 4 billion years ago, it was 30% dimmer than it is now. Earth should have been a ball of ice, Airapetian said, but evidence shows there was liquid water (life cannot form without it). So how did Earth heat up enough to sustain this water? Scientists call this the faint young Sun paradox (see <http://bit.ly/Reviews-Geophys-FaintSun>).

Today carbon dioxide drives warming of Earth’s atmosphere in a big way, but 4 billion years ago, if there had been enough CO₂ in the atmosphere to heat the planet, Earth’s oceans would have been too acidic for life to evolve, Airapetian said. Nitrous oxide, however, warms the atmosphere 300 times more effectively than CO₂. Even though N₂O was—and remains today—a small portion of the atmosphere, perhaps it played the major role in heating the planet, Airapetian and his colleagues propose in their 23 May paper.

The new study “is a viable additional piece in the long-scattered puzzle of how adequate supplies of biologically available nitrogen and a warm atmosphere were maintained during Earth’s earliest history,” said Timothy Lyons, a biogeochemist at the University of California, Riverside, who was not involved in the research. “This is an exciting idea that could kill two birds with one stone.”

Implications for Extraterrestrial Life

Beyond offering new insight into how early Earth might have become a crucible for life, the new work has broader implications, Airapetian said. “Our model expands the traditional definition of habitable zones of habitable exoplanets,” he noted. Now scientists can also consider exoplanets that may be orbiting young, energetic, Sun-like stars, where sufficient energy could become available to make organic molecules out of inorganic molecules.

In the habitable zone around a star, liquid water can persist on a planet’s surface, but a new type of habitable zone could be termed the “biogenic zone,” Airapetian said. There not only does water stay liquid, “but also the planetary atmosphere receives enough energy to make biomolecules of life, setting a pathway to [forming] RNA and DNA.”

He and his colleagues are also currently studying how super solar flares could have affected Mars.

Storms Cause Infrequent Turbulence for Aircraft, New Study Finds



Turbulence affecting air travel results from storms only about a sixth as often as other studies have estimated, new data suggest.

Past studies have found that convective storms, like thunderstorms, cause a large portion of turbulence that plagues commercial airliners. Using those findings, a research team in the United Kingdom recently set out to create an automated system for turbulence detection that relies on lightning sensors to alert airlines of dangerous winds.

Now, following the first tests of this new system, the researchers from the Met Office in Exeter have found that airplanes flying near convective storms experience much less turbulence than they expected: Just 14% of turbulence events were associated with convective storms.

This finding sharply contrasts with results of some previous studies that estimated that between 82% and 86% of turbulence encounters were associated with convective storms. The authors of the new study (see <http://bit.ly/JAMC-turbulence>) suggest that other sources of turbulence, such as winds forced up over mountain ranges, should receive a greater share of researchers’ attention in the future. The Met Office team published its results in the May issue of the *Journal of Applied Meteorology and Climatology*.

Some turbulence researchers found the numbers surprising. The frequency of turbulence from convective storms “seems a little low, at least compared to over the continental U.S.,” said Robert Sharman, an atmospheric scientist with the National Center for Atmospheric Research in Boulder, Colo., who was not involved with the new study.

The Met Office researchers used an unconventional tool to pinpoint turbulent locations: a network of lightning sensors scattered across Europe and North Africa. These

sensors can triangulate the location of lightning strikes. The areas with the most lightning strikes represented the centers of convective storms, the researchers said.

Comparing these data with more commonly used indicators of turbulence sources, including satellite imagery of clouds and velocity data from aboard airplanes, allowed the researchers to study the effects of turbulence from those storms on airplanes flying near them.

Sharman said he holds some doubts about the accuracy of lightning as a storm detection method, saying that lightning may not always be concentrated in the center of a storm. Moreover, he said, it’s not clear “just because there’s lightning that there’s turbulence.”

The new study’s disagreement with prevailing wisdom “may also indicate that convection is relatively less important as a source of turbulence over Europe and the northeastern Atlantic than over other regions (such as North America and the tropics),” the team noted in the paper’s conclusions. Many prior turbulence studies took place over North America.

However, Sharman said that it’s unlikely that significantly less turbulence occurs over Europe compared with North America.

The Met Office team ran its tests for two 6-month periods (May through October) in 2013 and 2014. The researchers noted that a future study “over a significantly longer time period” would help test the validity of the patterns they found.

By **Elizabeth Deatrick**, Writer Intern; email: edeatrick@agu.org

Advisory Panel Calls for Large Increase for Ocean Exploration

NOAA Office of Ocean Exploration and Research



The Okeanos Explorer carries out scientific research of the ocean for the National Oceanic and Atmospheric Administration.

In the United States, federal funding for exploration of the nation's offshore exclusive economic zone and of the global ocean should be much higher than currently budgeted, according to a recent letter that the Ocean Exploration Advisory Board (OEAB) sent to the National Oceanic and Atmospheric Administration (NOAA). The agency estab-

lished OEAB, an independent U.S. federal advisory committee, in 2014 to provide advice on ocean exploration to NOAA and the nation (see <http://bit.ly/OEABsite>).

The ocean exploration program within NOAA received approximately \$32 million for fiscal year (FY) 2016. However, in a 27 April letter to NOAA's chief scientist and other

agency officials, the board wrote that previous national studies "envision annual funding of \$75 million to execute ocean exploration activities." A report of the President's Panel for Ocean Exploration issued in 2000 recommended that amount (see <http://bit.ly/ocean-panel-report>).

The board's letter and a related one sent to NOAA administrator Kathryn Sullivan the same day also recommend that NOAA play a more proactive role in

coordinating ocean exploration among federal agencies. The board's letter calls upon NOAA also to work more vigorously to draw in federal and private funding for ocean exploration and to provide some specific ocean observations that are needed in certain regions, including the Arctic, among other measures. NOAA, through its Office of Ocean Exploration and Research (OER), coordinates the only federal program to systematically explore the oceans.

Board Chair Sets a Higher Funding Goal

"America's future depends on understanding the oceans," the OEAB mentioned in a statement that the group approved at its recent meeting about why more exploration is needed. "We explore the oceans because their health and resilience are vital to our economy and to our lives: climate, food, shipping, national security, medicine, and natural resources," the summary also said.

The U.S. national ocean exploration program "probably should be at least \$200 million," Vice Admiral Paul G. Gaffney II, U.S. Navy (Ret.), chair of the OEAB, told *Eos* in an interview. "I just think it hasn't earned all the respect that it's due yet."

The White House requested \$19 million for FY 2017, the same amount it requested for FY 2016, whereas the FY 2018 budget request, already in early formulation, shows hints of some improvement, according to OEAB (see <http://bit.ly/OEABchair-slides>).

"Given the budget resources that we have, can we accomplish everything?"

Gaffney said that NOAA, an agency within the Department of Commerce, doesn't have the same budgeting flexibility as the Department of Defense or even NASA and that it might be difficult to move funding around.

Alan Leonardi, NOAA's OER director, called the advice to the agency "positive." He did not comment specifically on budget levels but told *Eos* that "there are a lot of competing demands for federal resources."

Leonardi said he agrees with much of the board's advice to NOAA. "My reservations are that given the budget resources that we have, can we accomplish everything?" he said. He added that NOAA officials will respond to the board after reviewing the letters.

By **Randy Showstack**, Staff Writer

Call for Ocean Discovery Lecturers

The U.S. Science Support Program (USSSP) is seeking dynamic speakers to convey the excitement of the International Ocean Discovery Program (IODP) to geoscience communities and the United States public.

Since 1991, more than 750 presentations have been made to audiences at U.S. colleges, universities, and informal learning centers. Your help is requested to identify scientists interested in participating in the Ocean Discovery Lecture Series Program during the 2017-2018 academic year. Lectures focus on the discoveries and results of scientific ocean drilling and are primarily aimed at undergraduate and graduate students, museums, science departments, and the scientifically literate public.

If you or someone you know is interested in becoming an Ocean Discovery Lecturer, email their name, institution, and potential lecture topic to the USSSP Office (ussp@LDEO.columbia.edu) by the nomination deadline of July 22, 2016.

Deadline:
July 22, 2016



Extending Recent Seismic Imaging Successes to South America

Ambient Noise Tomography Workshop (MIMOSA)

Tucson, Arizona, 17–23 January 2016



Torres del Paine, Chile. What structures underlie these mountains and other features in South America?

One of the main scientific goals of the EarthScope transportable array (see <http://www.earthscope.org/>) is to investigate the structure, dynamics, and tectonic history of the North American continent. But what about South America?

Although South America does not have the seismic station distribution and near-real-time data access associated with a transportable array, a developing collection of national broadband seismic networks is beginning to populate the South American continent. In addition, there have been a large number of portable broadband deployments producing seismic data across South America.

The recent increase in instrumentation paired with growing interest from individual network operators to expand the scope of their seismic research capabilities has opened up the possibility of new collaborations with U.S. research institutions. With the ambitious goal of extending the recent seismic imaging successes of EarthScope to the South American continent, the Multiscale Imaging of Modern Orogenic South America (MIMOSA) project, funded by the U.S. National Science Foundation, aims to develop these mutually beneficial international collaborations (see <http://bit.ly/1TWPpYp>).

As part of the MIMOSA project, researchers from five South American countries along with other visiting researchers from around the world gathered at the University of Arizona in January for a weeklong workshop on ambient noise tomography (ANT). A seismic imaging technique refined by scientists working on EarthScope, ANT methods allow scientists to use low-amplitude background seismic noise to create images of the crust and uppermost mantle at depth. Because no earthquake source is needed, the technique can produce accurate cross sections from local to unprecedented continental scales.

Workshop participants included a wide range of scientists at different career stages, including seismic network operators, graduate students, postdoctoral researchers, and professors. Time spent during the workshop was split between presentations focusing on developing an understanding of the ANT methodology and work time for the participants to apply what they learned to their own data sets. In addition, the International Development Seismology section of the Incorporated Research Institutions for Seismology (IRIS) included a presentation that helped make all participants aware of the ser-

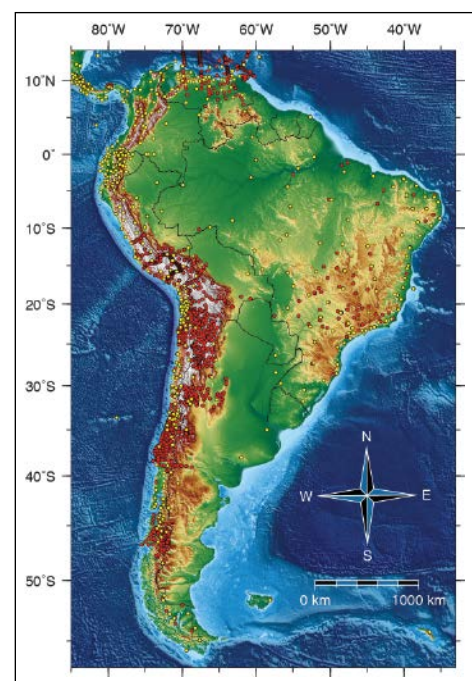
vices and potential collaborations available from the IRIS community.

The workshop concluded with all participants having a fundamental understanding of the ANT method and the ability to continue applying this method at their home institutions. To extend the ANT method across the South American continent, participants were encouraged to seek out additional collaborations with neighboring countries.

In view of the recent increase in broadband seismic networks in South America and growing interest among their operators, attendees agreed that more of these kinds of workshops are needed. A unique opportunity exists for researchers to cultivate this growing scientific interest through mutually beneficial international collaborations, leading to a better understanding of the geodynamic and tectonic history of the South American continent.

For more on this meeting, see <http://bit.ly/1sKuDvC>.

By **Kevin M. Ward**, **Jonathan R. Delph**, and **Susan L. Beck**, Geosciences Department, University of Arizona, Tucson; email: wardk@email.arizona.edu



Map of the South American continent showing known seismic stations appropriate for an ambient noise tomography (ANT) study. Portable station deployments are shown as red circles, and permanent stations are shown as yellow circles. Although significant spatial and temporal gaps still exist with the current station geometry, the potential for extending a continental-scale ANT study across South America is rapidly becoming a possibility.

Norway and Cuba Evaluate Bilateral Climate Research Results

XCUBE Workshop

Camagüey, Cuba, 16–18 November 2015



Juan Carlos Antuña-Sánchez

The Grupo de Óptica Atmosférica de Camagüey instruments at Camagüey Meteorological Centre in Camagüey, Cuba. From left to right, the Cimet-318 Sun photometer and the suction nose for the low-volume particle impactor are on the red roof of the instrument control room (small white structure). The GPS automatic meteorological station is the white cylindrical instrument behind and slightly to the right of the control room. The white sphere in the center rear is the RD-200SX Doppler radar, designed and built by the National Radar Center in Camagüey. The small gray dome on the far right is a GPS antenna.

Since 2013, the Future of Climate Extremes in the Caribbean (XCUBE) project has studied the vulnerability of the Caribbean to future climate extremes. XCUBE is funded by the Norwegian Directorate for Civil Protection on assignment of the Norwegian Ministry of Foreign Affairs. In November 2015, the Grupo de Óptica Atmosférica de Camagüey (GOAC; <http://www.goac.cu>) of the Cuban Meteorological Institute (INSMET) hosted an XCUBE workshop at which researchers discussed advances in bilateral scientific cooperation between Cuba and Norway on climate change.

Workshop participants discussed a recently published paper on sea surface temperature trends in observations and models for the Caribbean and the Antilles. A follow-up study looking at an intercomparison of station data and European Centre for Medium-Range

Weather Forecasts Reanalysis (ERA)-Interim Reanalysis for Cuba was also discussed (see <http://bit.ly/ERA-Interim>).

The results achieved are encouraging because they identify, quantify, and make preliminary attribution of ERA-Interim Reanalysis biases for Cuba. For example, the study found that 2-meter surface air temperature in the ERA-Interim model is warmer than observed. Further work will be conducted to compare temperature at mandatory levels from Caribbean sounding stations (based on the Integrated Global Radiosonde Archive data set) and ERA-Interim Reanalysis.

The workshop also included a visit to the Camagüey Meteorological Centre (CMC), the GOAC facilities, the National Radar Center, the CMC Forecast Department, and a local facility developed jointly by Norway and Cuba to conduct capacity-building activities. The Norwe-

gian Embassy in Cuba sees the contribution of researchers from Camagüey as an important part of the XCUBE project; the workshop and field visits were key to the collaboration. In addition, the World Food Program representatives in Cuba have expressed interest in the results of the ongoing (and upcoming) research, which are relevant for their food security assessment in Cuba.

The lessons learned from the XCUBE project and the workshop discussions have provided the framework for a new proposal for the continuation of XCUBE cooperation, which will have a major focus on the hydrological effects of climate change

and future food security for Cuba. Alan Robock from Rutgers University (New Brunswick, N.J.) will be leading the work on food security with the cooperation of Roger Rivero Vega from INSMET/Camagüey, an expert on potential climate change effects on food production. We expect that this and the next phase of the project will enhance scientific understanding of climate variability in the Caribbean.

By **Juan Carlos Antuña-Marrero**, Grupo de Óptica Atmosférica de Camagüey, Meteorological Institute, Camagüey, Cuba; email: anadelia@caonao.cu; **Michel d. S. Mesquita**, Uni Research Climate and the Bjerknes Centre for Climate Research, Bergen, Norway; and **Albeth Rodríguez**, Grupo de Óptica Atmosférica de Camagüey, Meteorological Institute, Camagüey, Cuba

Creating Career Paths for African-American Students in Geosciences

By Robert Liebermann, Lars Ehm, and Gabriel Gwanmesia



On the morning of 6 February 2015, Melissa Sims walked the short path to the podium in the lecture hall of the newly constructed National Synchrotron Light Source II facility, a building of Brookhaven National Laboratory. This was no ordinary lecture. At age 28, Sims was a graduate student studying how feldspar minerals compress during meteorite impacts. In the audience sat Secretary of Energy Ernest Moniz, whom she was tasked with introducing at the new facility's dedication.

It's not every day that a graduate student gets to open for a cabinet member. Rarer still is Sims, an African-American woman geoscientist in a field dominated by white men. As she sat on stage, Sims



Brookhaven National Laboratory

Melissa Sims from Stony Brook University (right) introducing Secretary of Energy Ernest Moniz (left) at the dedication of the National Synchrotron Light Source (NSLS) II facility in February 2015 with NSLS director Steve Dierker (far right) looking on.

remembers thinking, “How did I end up here, on a stage with someone appointed by the president?”

Sims is the product of a new initiative at Stony Brook University called “A Career Path for African-American Students from Historically Black Colleges and Universities to National Laboratories.” The initiative teaches marketable skills, places students in internships, and fosters the professional career tracks of underrepresented minorities. We offer this initiative as a proof of concept example of how and what institutions can do to address the shortage of African-Americans in the geosciences.

The Scope of Underrepresentation

The geosciences have the lowest African-American representation of all the science, technology, engineering, and mathematics disciplines [Huntoon *et al.*, 2015].

A report from the American Institute of Physics entitled “Untapped Talent: The African American Presence in Physics and the Geosciences” [Czujko *et al.*, 2008] gives some background on the root causes of this underrepresentation.

The report emphasizes that although many African-American students have the necessary high school backgrounds to succeed in physics, “these prepared students are more likely to choose math or sciences other than physics and geosciences.” In fact, “compared to other scientific disciplines, physics and the geosciences consistently come out near the bottom in terms of their ability to attract and retain African Americans,” the report notes [Czujko *et al.*, 2008]. For example, in 2004, 4% of African-American undergraduates earned a bachelor’s degree in physics and only 2% in the geosciences (compared with 9% for all sciences, which is still below the 13% of African-Americans in the U.S. population).

Czujko *et al.* [2008] also examine the state of African-Americans within the larger context of the U.S. educational system and social structure, including geography and economics. Most African-American students go to college near their homes, and more than 70% of U.S. universities and colleges awarded no bachelor’s degrees in the geosci-

ences to African-Americans in the 5-year period of 2000–2004.

The dearth of degrees awarded to African-Americans is even more pronounced at the master’s level, despite the fact that more than 500,000 such degrees are awarded each year in the United States. As the report notes, “The geosciences have the unenviable distinction of having the poorest representation of African Americans (1%) among master’s degree recipients” [Czujko *et al.*, 2008].

Framework for Training and Employment

To address this poor record, the National Science Foundation (NSF) Directorate for Geosciences established in 2006 a program called Opportunities for Enhancing Diversity in the Geosciences (OEDG). Stony Brook’s new initiative is a product of OEDG.

The initiative has a few key steps. First, project leaders seek to recruit undergraduate science and engineering students from underrepresented groups into the graduate program in the Department of Geosciences at Stony Brook University. For expediency, efforts are focused on historically black colleges and universities, such as Delaware State University.

Next, the recruited students take courses and develop research projects toward an M.S. in geosciences instrumentation—a degree provided by Stony Brook. Thus far, project leaders have chosen to focus on instrumentation so that students could develop marketable skill sets in an emerging field between science and technology.

Finally, students receive training that prepares them for employment as science associates in national user facilities of the U.S. Department of Energy. All graduates of the program have conducted their research projects at the National Synchrotron Light Source (NSLS) of the Brookhaven National Laboratory (BNL).

Building on Existing Foundations

The new program has taken advantage of the long-standing relationship between professors from historically black colleges and universities and BNL. An important element of this relationship is the Interdisciplinary Consortium for Research and Educational Access in Science and Engineering (INCREASE), an organization that supports access to research facilities not typically available to faculty at historically black colleges and universities (see <http://www.increaseonline.org/>). To enhance its ability to attract African-American undergraduates, Stony Brook University has capitalized on its connection with colleagues in INCREASE institutions to help identify and recruit students.

In addition to INCREASE and NSLS at BNL, partners in this new initiative include the Center for Inclusive Education and the Graduate School of Stony Brook University (see <http://bit.ly/1Zc41hJ>). All of these organizations have provided matching funds to complement the National Science Foundation support.

The M.S. in geosciences instrumentation program includes both formal courses and hands-on research proj-



Lars Ehm

(left to right) Melissa Sims, Adairé Heady, and Ashley Thompson examining one of NSLS's beamlines. Beamlines are paths for accelerated particles, used in this case to study properties of crystal structures.

ects at the NSLS. The projects typically involve the study of the physical and chemical properties of minerals under high-pressure conditions, which is the major focus of the Consortium for Materials Properties for Research in Earth Sciences, which operates synchrotron beamlines for high-pressure research in the United States.

Program Successes

To date, the initiative has graduated three M.S. students: Ashley Thompson from Delaware State University, Melissa Sims from the University of South Carolina, and Adairé Heady from Delaware State University. All graduated from Stony Brook within a 2-year period.

Thompson is now in a Ph.D. program in mechanical engineering at Stony Brook; Sims, who was awarded a prestigious graduate fellowship from Stony Brook, is studying for her doctorate in geosciences at the university; and Heady is seeking employment at a national laboratory such as BNL.

In September 2014, Brandon Rhymer from the University of the Virgin Islands enrolled in Stony Brook's initiative. He graduated with his M.S. degree in May 2016 and is

returning to his home institution to teach for a year before deciding whether to pursue further graduate study.

Stony Brook's program shows how science-minded students, through mentoring and research opportunities, can change their expectations to embrace geoscience research. For example, Sims was an undergraduate in exploration geophysics and headed toward a career in the oil industry. But when she learned about Stony Brook's program, she shifted her ambitions to a more academic direction. Similarly, Rhymer initially was considering opportunities in engineering but changed his focus to study geophysics after spending two summers at BNL in the Science Undergraduate Laboratory Internship program (see <http://1.usa.gov/1X0leiB>).

The Future

The NSF Directorate for Geosciences has approved a no-cost extension of Stony Brook's grant, which allows the program's time period to run to 2016. Unfortunately, NSF has temporarily suspended funding for the OEDG program, so Stony Brook is seeking new funding to extend the program beyond 2016. However, both Brookhaven National Laboratory and the Graduate School at Stony Brook have extended their funding for another 2 years.

For tips on how to implement such a program in your institution, contact Robert Liebermann.

References

- Czujko, R., R. Ivie, and J. H. Stith (2008), Untapped talent: The African American presence in physics and the geosciences, *Publ. R-444*, 22 pp., Am. Inst. of Phys., College Park, Md.
- Huntoon, J. E., C. Tanenbaum, and J. Hodges (2015), Increasing diversity in the geosciences, *Eos*, 96, doi:10.1029/2015EO025897.

Author Information

Robert Liebermann, Department of Geosciences and Mineral Physics Institute, Stony Brook University, Stony Brook, N.Y.; email: robert.liebermann@stonybrook.edu; **Lars Ehm**, Mineral Physics Institute, Stony Brook University, Stony Brook, N.Y., and Brookhaven National Laboratory, Upton, N.Y.; and **Gabriel Gwanmesia**, Department of Physics and Engineering, Delaware State University, Dover



Gabriel Gwanmesia

Brandon Rhymer with the 2000-ton uniaxial split sphere apparatus in the Stony Brook High Pressure Laboratory. The apparatus helps scientists simulate the high pressures of Earth's deep interior.



UNDERSTANDING **VOLCANIC ERUPTIONS** WHERE PLATES MEET

By Raffaele Azzaro and Rosanna De Rosa

**A new project clarifies the relationships
between tectonics and volcanic systems
and how they influence hazards on Italy's
Mount Etna and Vulcano and Lipari islands.**

Mount Etna erupting at dusk.



Antonio Zimbone/AGF/UG/Getty Images

Mount Etna and the Aeolian Islands in southern Italy represent ideal natural laboratories to study how magma and tectonics interact in active volcanic zones and their associated hazards. The geodynamic context of both areas is characterized by a tectonic compression running north and south, related to the convergence of the African and Eurasian plates in the central Mediterranean (Figure 1). This compression creates

a cluster of volcanoes, some of the most active in Europe.

The region's proximity to major urban centers is a double-edged sword. Researchers have little trouble visiting volcanoes to study how tectonics influence volcanic plumbing. At the same time, this proximity presents hazards to inland communities and those on nearby shores.

To take advantage of this natural laboratory and to help protect people living nearby, several branches of Italy's government research community established the V3 Project—so



The active crater of Vulcano (in the background) viewed from Lipari, in Italy's Aeolian Islands. The cliffs in the foreground are governed by tectonics.

named because it is project number 3 of the Italian Civil Protection Department's Volcanological Research Program. Data collection for the project ran from 2012 to 2015; now researchers are analyzing the data to build better hazards maps and strengthen understanding of how tectonic and volcanic processes work together to exacerbate risk.

Tectonic Setting

A remnant of the Ionian slab (African plate) is subducting toward the northwest beneath the Calabrian Arc, which forms the toe of Italy's boot [Gvirtzman and Nur, 2001]. The resulting Tindari Fault is a right-lateral strike-slip structure capable of generating moderate earthquakes (the most recent event, in 1978, was $M_{6.2}$) that extends from the central sector of the Aeolian Archipelago (islands of Vulcano and Lipari) in the southern Tyrrhenian Sea toward the Etna region to the south [Billi et al., 2006]. This tectonic feature, located in eastern Sicily, is considered to represent a stress transfer zone between the two volcanic areas [De Guidi et al., 2013].

A System of Volcanoes

Mount Etna (3340 meters above sea level) is the most active volcano in Europe. It features nearly constant summit activity and frequent flank eruptions, with extended lava flows and copious ashfall. Its activity has increased significantly in recent years—not only are eruptions more

frequent, but also the volcano emits a greater volume of lava.

At Vulcano and Lipari, in the Aeolian Islands, volcanic unrest is much less frequent but produces more intense explosive activity and emissions of viscous and thick lava flows. The previous outbreak at Lipari, in 1230, produced a renowned eruption of pumice and obsidian. Vulcano erupted more recently, in 1888–1890, but since then it has exhibited only high-temperature fumarolic activity.

The hazards in active volcanic areas are generally related to eruptive activity: lava and flows of hot gas and rock, tephra fallout, fast moving mudflows (lahars), or volcanic gas emissions. However, other less devastating kinds of events may also threaten local communities living on the flanks of a volcano, mostly because these events occur frequently or almost continuously.

At Etna, recurrent volcano-tectonic seismicity poses a serious hazard to the 400,000 or so people who live in urbanized areas and to important infrastructure (roads, water/gas/power lines, hospitals, schools, etc.) [Azzaro et al., 2016]. At Vulcano, rockfalls and landslides affecting the active crater put the village and its tourist facilities at risk [Marsella et al., 2015]. These instabilities can happen unexpectedly because of variations in volcanic activity or such other triggering processes as rainfall and seismic activity. Ongoing sea flooding in Lipari's main town provides overwhelming evidence of land subsidence that, coupled with the expected sea level rise in the

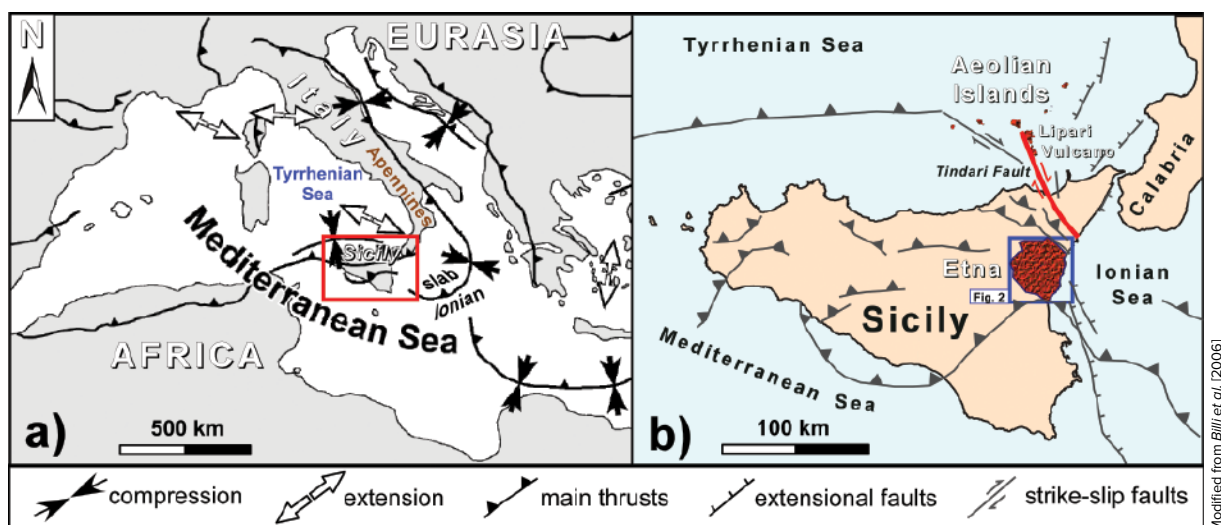


Fig. 1. (a) Tectonic map showing the geodynamic framework of the Mediterranean region. (b) Main structural features of Sicily and location of the volcanic areas studied in the V3 Project.

next decades [Anzidei *et al.*, 2014], will lead to future permanent inundations.

Addressing the Issues

To tackle hazards and risk in this seismically active volcanic zone, the Italian Civil Protection Department (DPC), with the National Institute of Geophysics and Volcanology (INGV, through branches in Catania, Palermo, and Rome), three Italian universities (Cosenza, Catania, and Rome), and the National Institute of Oceanography and Experimental Geophysics (Trieste), launched the V3 Project.

According to the project's mission statement, V3 aimed to develop "multidisciplinary analysis of the relationships between tectonic structures and volcanic activity." The project extended previous research programs on the same areas funded by DPC. It dealt with various methodological approaches—tectonic, geophysical, geochemical, petrological, and geotechnical investigations—to interpret ongoing phenomena and assess related hazards.

The V3 Project had four goals:

- to define the tectonic framework controlling the volcanic systems
- to analyze the exceptionally long time series of instrumental data acquired by the multiparametric monitoring and define the relationships among them
- to characterize processes connected with the interaction between tectonic structures and volcanic systems
- to produce hazards maps aimed at mitigating the effects of earthquakes, landslides, and land subsidence

The results of the project have been presented at conferences and are being published in technical reports [Azzaro and De Rosa, 2016] and scientific papers.

Assessing Hazards at Etna

As a result of the V3 Project, we now have a greater understanding of the volcanic and tectonic mechanisms that drive hazards in the region.

We found significant correlations in the eastern flank of Etna among active fault zones, seismic patterns, variations of crustal geodetic strain, and fluids circulation. This opens new perspectives to understand faulting at Etna. We have obtained an analytical estimation of creep processes, indicating that about 40% of the deformation occurs aseptically. Moreover, we recognized that the pore pressure of fluids circulating in the volcanic rocks (chiefly groundwater) depends on variations in the crustal strains related to volcanic or seismic activity [Mattia *et al.*, 2015].

We performed a full probabilistic seismic hazards assessment




Scientists measure land subsidence effects along the shoreline of Lipari.



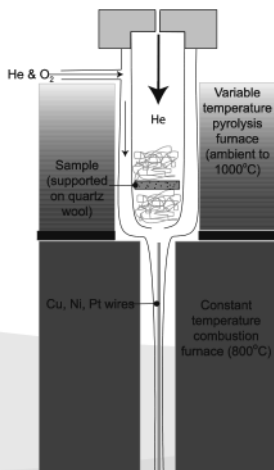
C. Federico

Scientists sample bubbling gases from mofettes—vents where chiefly carbon dioxide escapes—around Etna.



NOSAMS
NATIONAL OCEAN SCIENCES
ACCELERATOR MASS SPECTROMETRY

NSF-Sponsored Workshop
Thermal Analysis of Natural Organic Matter
Sept. 15-16, 2016, Woods Hole, MA



NOSAMS is sponsoring a workshop on a new thermal analysis technique, Ramped PyrOx (RPO), at the Woods Hole Oceanographic Institution. Using RPO, a sample containing organic matter is pyrolyzed or oxidized at a constantly increasing temperature and the CO₂ evolved is collected at discrete intervals for radiocarbon analysis. It has been applied to Antarctic sediment chronologies, age distributions in sediments and soils, the age spectrum of dissolved organic carbon, and atmospheric particulate matter. The workshop will explore future applications and instrumental/methodological limitations.

Space is limited for the workshop; to express interest in attending, or to access other information, please visit www.whoi.edu/nosams/rpo

at Etna through local seismic sources defined with instrumental and historic earthquake data sets [Azzaro *et al.*, 2015]. The obtained estimations (Figure 2) show that relevant values of ground accelerations are probabilistically likely to occur also in short times (5–30 years) and are intended to complement the 50-year seismic hazards map of Italy [Stucchi *et al.*, 2011]. The assessment can be used to establish priorities for seismic retrofitting of the more exposed municipalities.

V3 efforts improved knowledge of the geometry and structural setting of the sedimentary basement underlying Etna using high-resolution aeromagnetic surveys and offshore seismic profiles. They reveal magnetic anomalies associated with important faults [Nicolosi *et al.*, 2014] and shallow-seated batches of crystallized magma in a framework of active compressive and extensional tectonic structures related to the African plate colliding with Europe [Polonia *et al.*, 2016].

Hazards Elsewhere

The regional pattern of north–south crustal shortening in the southern sector of the Aeolian Islands is associated with a diffuse subsidence [Esposito *et al.*, 2015], but at a local scale the dynamics reflect different processes (Figure 3a). At Vulcano a shallow (4-kilometer-deep) deflating magmatic source in the northernmost part of the island is periodically fed by deep fluids coming from the underlying reservoir. At Lipari, long-term land subsidence [Anzidei *et al.*, 2016] is enhanced by coastal dynamics (retreating of submarine canyons into the shelf), with a maximum sea level rise of up to 2.2 meters expected in 2100.

We confirmed the existence of a common plumbing system responsible for the historic eruptions (less than 1000 years ago) of Lipari and Vulcano. This plumbing system, which lies at a depth of 20 kilometers, periodically feeds shallow magma storage zones where processes of magma crystallization occur [Fusillo *et al.*, 2015]. The eruptive activity took place contemporaneously at both islands along a narrow zone characterized by a dominant east–west extensional stress field (Figure 3b). Any future eruption is likely to take place in this narrow zone [Ruch *et al.*, 2016].

The susceptibility of the active crater of Vulcano to landslides, which endanger the main village, is enhanced by hydrothermal alteration of rock mass due to hydrothermal fluid circulation (fumarolic fields, indicated by red in Figure 3a). Fractures and volcano stratigraphic discontinuities control the locations of areas potentially affected by shallow (debris avalanches/flows and rockfalls) and deep-seated instability processes [Cangemi *et al.*,

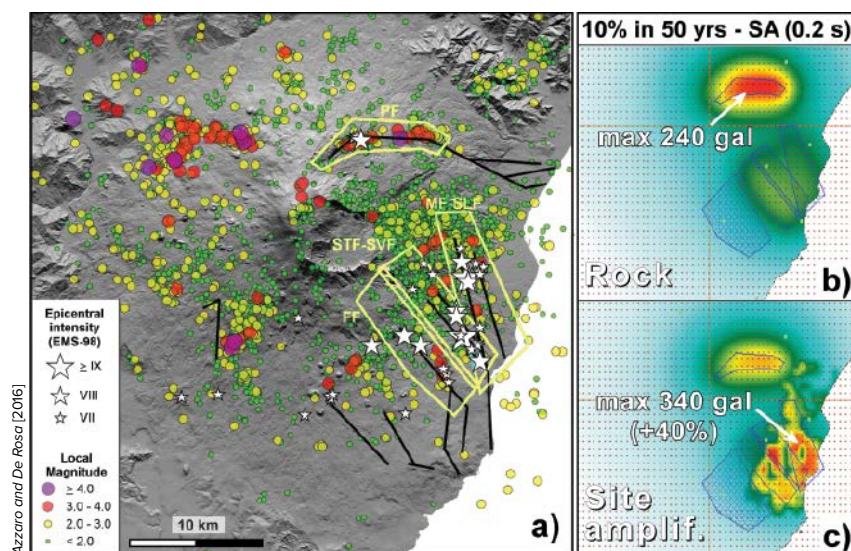


Fig. 2. (a) Shallow (depth ≤ 5 kilometers) seismicity recorded at Mount Etna from 2005 to 2014 (circles) and main historic, damaging earthquakes (stars) occurring since 1600. Areas enclosed in yellow lines indicate the studied seismic zones embracing active faults (black lines): FF, Fiandaca; MF-SLF, Moscarello–San Leonardello; PF, Pernicana; STF-SVF, Santa Tecla–Santa Venerina. (b) Example of probabilistic seismic hazards map: spectral acceleration at 0.2 second, probability of exceedance of 10% calculated for an exposure time of 50 years. (c) Relevance of local site amplification effects on the maximum value of expected acceleration due to shaking. Colors in Figures 2b and 2c represent the values of estimated ground acceleration, from red (maximum) to blue (minimum, close to zero).

2016]. This makes large rock volumes prone to slide suddenly, as occurred in 1988.

Science to Mitigate Risk

Similar to other coordinated research funded by DPC, the findings of the V3 Project represent the efforts of the scientific community to provide authorities with appropriate instruments to mitigate risks in volcanic areas. To do this, V3 endeavored to improve knowledge on inadequately studied processes.

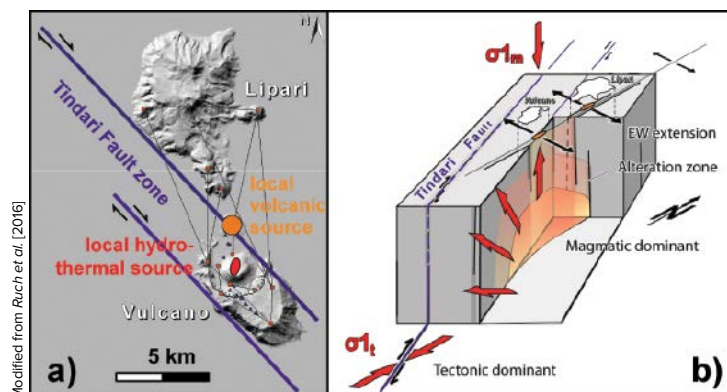


Fig. 3. The Vulcano-Lipari system (Aeolian Islands). (a) Location of the regional (Tindari) Fault zone, responsible for the M6.2 1978 earthquake and volcanic sources acting in this region. Red squares with connected lines are GPS and electronic distance measurement networks; blue triangles are leveling benchmarks. (b) Sketch to explain the transition from strike-slip kinematics along the Tindari Fault (horizontal tectonic stress (σ_H) dominant) to extension (vertical magmatic stress (σ_M) dominant, orange in Figure 3a) responsible for magma intrusions in the past 20,000 years.

Full assessments can be found on V3's Web pages (<http://bit.ly/20Ss8mk>).

References

- Anzidei, M., et al. (2014), Coastal structure, sea-level changes and vertical motion of the land in the Mediterranean, *Geol. Soc. Spec. Publ.*, 388, 453–479, doi:10.1144/SP388.20.
- Anzidei, M., et al. (2016), New insights on the subsidence of Lipari island (Aeolian Islands, southern Italy) from the submerged Roman age pier at Marina Lunga, *Quat. Int.*, 401, 162–173, doi:10.1016/j.quaint.2015.07.003.
- Azzaro, R., and R. De Rosa (2016), Project V3: Multi-disciplinary analysis of the relationships between tectonic structures and volcanic activity (Etna, Vulcano-Lipari system), final report, Misc. INGV 29, 1722 pp., Ist. Naz. di Geofis. e Vulcanol., Rome. [Available at <https://sites.google.com/ingv.it/volcpro2014/>]
- Azzaro, R., et al. (2015), Towards a new generation of seismic hazard maps for the volcanic region of Mt. Etna, in *Proceedings of the 34th NGT Meeting*, 17–19 November 2015, Trieste (Italy), pp. 5–11, Ist. Naz. di Oceanogr. e di Geofis. Sper., Trieste, Italy.
- Azzaro, R., S. D'Amico, and T. Tuvè (2016), Seismic hazard assessment in the volcanic region of Mt. Etna (Italy): A probabilistic approach based on macroseismic data applied to volcano-tectonic seismicity, *Bull. Earthquake Eng.*, doi:10.1007/s10518-015-9806-2, in press.
- Billi, A., et al. (2006), Tectonics and seismicity of the Tindari Fault System, southern Italy: Crustal deformations at the transition between ongoing contractional and extensional domains located above the edge of a subducting slab, *Tectonics*, 25, TC2006, doi:10.1029/2004TC001763.
- Cangemi, M., et al. (2016), Shallow hydrothermal alteration and permeability changes in pyroclastic deposits: A case study at La Fossa cone (Vulcano Island, Italy), *Geophys. Res. Abstr.*, 18, EGU2016-2821-1.
- De Guidi, G., et al. (2013), Multidisciplinary study of the Tindari Fault (Sicily, Italy) separating ongoing contractional and extensional compartments along the active Africa–Eurasia convergent boundary, *Tectonophysics*, 588, 1–17, doi:10.1016/j.tecto.2012.11.021.
- Esposito, A., et al. (2015), Eighteen years of GPS surveys in the Aeolian Islands (southern Italy): Open data archive and velocity field, *Ann. Geophys.*, 58, S0439, doi:10.4401/ag-6823.
- Fusillo, R., et al. (2015), Deciphering post-caldera volcanism: Insight into the Vulcanello (Island of Vulcano, southern Italy) eruptive activity based on geological and petrological constraints, *Bull. Volcanol.*, 77, 76, doi:10.1007/s00445-015-0963-6.
- Gvirtzman, Z., and A. Nur (2001), Residual topography, lithospheric structure and sunken slabs in the central Mediterranean, *Earth Planet. Sci. Lett.*, 187, 117–130, doi:10.1016/S0012-821X(01)00272-2.
- Marsella, M., et al. (2015), Terrestrial laser scanning survey in support of unstable slopes analysis: The case of Vulcano Island (Italy), *Nat. Hazards*, 78, 443–459, doi:10.1007/s11069-015-1729-3.
- Mattia, M., et al. (2015), A comprehensive interpretative model of slow slip events on Mt. Etna's eastern flank, *Geochim. Geophys. Geosyst.*, 16, 635–658, doi:10.1002/2014GC005585.
- Nicolosi, I., et al. (2014), Volcanic conduit migration over a base ment landslide at Mount Etna (Italy), *Sci. Rep.*, 4, 5293, doi:10.1038/srep05293.
- Polonia, A., et al. (2016), The Ionian and Alfeo-Etna fault zones: New segments of an evolving plate boundary in the central Mediterranean Sea?, *Tectonophysics*, 675, 69–90, doi:10.1016/j.tecto.2016.03.016.
- Ruch, J., et al. (2016), Magmatic control along a strike-slip volcanic arc: The central Aeolian arc (Italy), *Tectonics*, 35, 407–424, doi:10.1002/2015TC004060.
- Stucchi, M., et al. (2011), Seismic hazard assessment (2003–2009) for the Italian building code, *Bull. Seismol. Soc. Am.*, 101(4), 1885–1911, doi:10.1785/0120100130.

Author Information

Raffaele Azzaro, Osservatorio Etneo, Istituto Nazionale di Geofisica e Vulcanologia, Catania, Italy; email: raffaele.azzaro@ingv.it; and **Rosanna De Rosa**, Dipartimento di Scienze della Terra, Università della Calabria, Arcavacata di Rende (CS), Italy

How on Earth to Decide Where on Mars to Land?



An artist's concept of a rover on the Martian surface. The Mars 2020 rover will resemble the Curiosity vehicle shown in this image.

Before NASA's next robotic explorer of the Red Planet can collect geological samples, complete measurements, and take "selfies" like its predecessor Curiosity, the Mars 2020 rover has to successfully land. Deciding on a landing spot for rovers or humans is no trivial task. Three experts—an astrobiologist, a geomorphologist, and a high school student talented in planetary science—will discuss the process behind selecting a landing site during the Public Lecture at this year's AGU Fall Meeting in San Francisco, Calif.

"The search for the best landing site is an exciting science discussion about Mars—what we know, what we think we know, and what we really don't know," according to astrobiologist and lead scientist of the Mars Exploration Program at NASA Michael Meyer, who will speak first in the Sunday, 11 December, panel.

The Mars 2020 mission seeks to build on discoveries made by previous rovers (Spirit, Opportunity, and Curiosity) by expanding our understanding of the potential for past or present life beyond Earth. Although we think of Mars as a cold, red-toned rockscape with a razor-thin atmosphere, the planet once harbored expansive oceans and a thick sheath of atmospheric gases. The Curiosity rover, one of NASA's flagship missions, which landed in August 2012, has advanced our understanding

of Mars in areas ranging from geochemistry to paleoclimate and has collected images on scales from micrometers to kilometers. The 2020 rover will study the rocks and soil of the new landing site and gain further insights into the planet's geological and astrobiological history. In addition, Mars 2020 will collect and store on the surface of Mars a set of soil and rock samples that could be picked up and returned to Earth by a future mission.

February 2021 marks the scheduled landing date for the new rover, which will spend at least one Mars year (two Earth years) on the Red Planet. Deciding where and how the rover will land rests with a collaborative team of the best and brightest engineers and scientists. Tasked with sorting through 27 terabytes of data, the team uses high-resolution images gained from orbiters to identify specific minerals in the terrain and then must patiently wade through a multitude of scenarios. Meyer noted that an improved ability of the Mars 2020 spacecraft to precisely identify where it is above the Martian surface, called "terrain relative navigation," will expand the pool of potential landing sites, giving the team "even more spectacular places to compare" and leading to "the hard part, deciding on the one place on Mars to explore."

Each of the three Public Lecture speakers came to a spot on the upcoming panel via a

unique trajectory, but all are united by their fascination with Mars. Their backgrounds speak to the power of collaborative work and diverse teams. These three experts involved in planning the Mars 2020 mission will provide a lively discussion and question and answer session:

- Michael Meyer does research primarily on microorganisms living in extreme environments. As one of the Mars 2020 mission's architects and leaders, he will provide key insights about the mission (see <http://bit.ly/Meyer-webpage>).

- Bethany Ehlmann's specialties include sorting out the compositional surface, environmental change, and weathering processes on the Red Planet. She has lent her expertise to the exploration of Mars since she first served as a student scientist collaborator for the Spirit and Opportunity missions (see <http://bit.ly/Ehlmann-Caltech>). She said that when running a Mars rover mission from Earth, the mission team shares "a strange, slightly jet-lagged experience of living on Mars time together."

- Alex Longo, a rising junior at Cardinal Gibbons High School in Raleigh, N.C., became fascinated with planetary science before he could read, leading him to this unique role for a high schooler. Longo notes the importance to his career plans of the Spirit rover, which "transformed Mars from a distant place I was taught about in a book to a dynamic place that I could visit someday." He participates in numerous NASA planetary activities and presented at landing site selection conferences in 2014 and 2015 alongside NASA scientists (see <http://bit.ly/Longo-article>).

Save the date—Sunday, 11 December 2016, from noon to 1:00 p.m., Pacific Standard Time (PST)—to learn more at AGU's Public Lecture about what leads up to the event that Meyer describes as the "existential moment" of landing a rover on Mars.

This annual public talk is free, family friendly, and geared toward nonscientists. No reservation is required. Each year, the Public Lecture strives to connect AGU members with the public—in this case, scientists at Fall Meeting with local San Francisco Bay Area residents.

Immediately following the lecture, Exploration Station, a free event lasting until 5:00 p.m. PST, will provide a rich assortment of hands-on science activities for families and children of all ages. For more information on both of these events, visit AGU's education programs website (<http://bit.ly/AGU-Education-PublicOutreach>).

By **Claire Wilson**, Intern, Education and Public Outreach, AGU; e-mail: cwilson@agu.org

Recognizing 2015 Reviewers for AGU

Reviewers play an essential role in the journals and books of AGU. They elevate quality and help authors and editors to improve the content, organization, logic, integrity, and impact of published papers.

Once again, AGU recognizes reviewers across all our journals and for Eos.org who provided exceptional reviews during the past year; outstanding reviewers for 2015 are listed below. Many of these, and other reviewers also, reviewed multiple times; we had several reviewers who provided more than 15 reviews just for AGU over the course of the year.

AGU provides other recognition as well to reviewers: Each AGU journal is publishing an editorial acknowledging all of its reviewers, and AGU now officially recognizes their reviews on their Open Researcher and Contributor Identification (ORCID) record, if requested.

Appreciation for Reviews and More

We hope that these multiple forms of acknowledgment and appreciation of reviewers provide both individual thanks

and prominent collective recognition of the importance of peer reviews in advancing science. Reviewing for publications represents just one way in which many scientists provide additional effort and benefit for their scientific community and society overall. Many of these same AGU reviewers also assess grants, advise on promotions, and contribute to departmental reviews for their home institutions or others.

Expanding Reviewer Diversity

We consider it important for the scholarly community to recognize this full picture and find ways to better reward these volunteer contributions while improving efficiency. AGU editors have been striving to expand the diversity of reviewers as one way to make efficiency gains as well as to help develop new scientists. AGU journals receive and publish papers from authors worldwide—about one third of submissions come from each of North America, Europe, and Asia/Australasia. In keeping with our move toward greater diversity, we recognize this year reviewers from

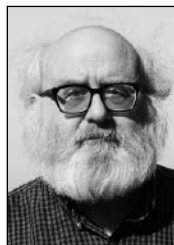


19 countries, including about 30% women—up in both measures from earlier years.

By **Brooks Hanson**, AGU Director of Publications;
email: bhanson@agu.org; and **Rob van der Hilst**,
Chair, AGU Publications Committee



Jennifer Adam
Cited by Ben van der Pluijm
Earth's Future



Duncan Carr Agnew
Cited by Uri ten Brink
JGR: Solid Earth



Newsha Ajami
Cited by Alberto Montanari
Water Resources Research



John T. Allen
Cited by Noah Diffenbaugh
Geophysical Research Letters



Anton V. Artemyev
Cited by Benoit Lavraud
Geophysical Research Letters



Kirsti Ashworth
Cited by James Crawford
JGR: Atmospheres



Jean-Philippe Avouac
Cited by Andrew Newman
Geophysical Research Letters



Rebecca Barnes
Cited by Miguel Goni
JGR: Biogeosciences



Max Berkelhammer
Cited by Allison Steiner
JGR: Atmospheres



Daniele Bianchi
Cited by Tatiana Ilyina
Geophysical Research Letters



Andrea Billi
Cited by Claudio Faccenna
Tectonics



Kristie Boering
Cited by Geoffrey Tyndall
Geophysical Research Letters



Diogo Bolster
Cited by M. Bayani Cardenas
Geophysical Research Letters



Bruce Buffett
Cited by Michael Wyession
Geophysical Research Letters



Michael Scott Chaffin
Cited by William Peterson
Geophysical Research Letters



Eric Christian
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Housen Chu
Cited by Ankur Desai
JGR: Biogeosciences



Ingrid Cnossen
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Mihail V. Codrescu
Cited by Phil Wilkinson
Radio Science



Laura E. Condon
Cited by Noah Diffenbaugh
Geophysical Research Letters



Tim M. Conway
Cited by Mary-Elena Carr
Global Biogeochemical Cycles



Vernon Cormier
Cited by Michael Wyession
Geophysical Research Letters



Ingrid J. Daubar
Cited by David Baratoux
JGR: Planets



Eric Debayle
Cited by Uri ten Brink
JGR: Solid Earth



Emily Riley Dellaripa
Cited by Chidong Zhang
JGR: Atmospheres



Blaize A. Denfeld
Cited by Miguel Goni
JGR: Biogeosciences



Sebastian Dötterl
Cited by Susan Trumbore
Global Biogeochemical Cycles



Samuel Doyle
Cited by Wendy S. Gordon
Eos



Douglas Edmonds
Cited by M. Bayani Cardenas
Geophysical Research Letters



Katherine Ellins
Cited by Carol A. Stein
Eos



Jerry P. Fairley
Cited by Alberto Montanari
Water Resources Research



Xueshang Feng
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Ken Ferrier
Cited by *JGR: Earth Surface* Editors
JGR: Earth Surface



Baylor Fox-Kemper
Cited by Lisa Beal
Geophysical Research Letters



Ryoichi Fujii
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Jason Furtado
Cited by Kim Cobb
Geophysical Research Letters



Dennis L. Gallagher
Cited by William Peterson
Geophysical Research Letters



Nicholas R. Golledge
Cited by Julianne Stroeve
Geophysical Research Letters



Salvatore Grimaldi
Cited by Alberto Montanari
Water Resources Research



Jasper Halekas
Cited by Andrew J. Dombard
Geophysical Research Letters



Roberta C. Hamme
Cited by Sara Mikaloff Fletcher
and Mary-Elena Carr
Global Biogeochemical Cycles



Jeanne L. Hardebeck
Cited by Uri ten Brink
JGR: Solid Earth



Ciaran Harman
Cited by M. Bayani Cardenas
Geophysical Research Letters



Judith Haschenburger
Cited by *JGR: Earth Surface* Editors
JGR: Earth Surface



Judith Hauck
Cited by Tatiana Ilyina
Geophysical Research Letters



Katharine R. Hendry
Cited by Ellen Thomas and Heiko Paelike
Paleoceanography



Stephanie Henson
Cited by Tatiana Ilyina
Geophysical Research Letters



Tessa Hill
Cited by Kim Cobb
Geophysical Research Letters



Ann Holbourn
Cited by Ellen Thomas and Heiko Paelike
Paleoceanography



Mashor Housh
Cited by Alberto Montanari
Water Resources Research



Martin Hurst
Cited by Michael Ellis
Earth's Future



Jennifer Hutchings
Cited by Andrey Proshutinsky
JGR: Oceans



Yoshihiro Ito
Cited by Andrew Newman
Geophysical Research Letters



Jennifer Jackson
Cited by Andrey Proshutinsky
JGR: Oceans



Bijaya B. Karki
Cited by Michael Wyssession
Geophysical Research Letters



Ryuho Kataoka
Cited by Benoit Lavraud
Geophysical Research Letters



Richard Katz

Cited by Thorsten Becker

Geochemistry, Geophysics, Geosystems



Gemma Kelly

Cited by Michael Hapgood

Space Weather



Sonia Kreidenweis

Cited by Lynn Russell

JGR: Atmospheres



Jian Lan

Cited by Leo Oey

JGR: Oceans



Michelle L'Heureux

Cited by Paul D. Williams

Geophysical Research Letters



Manuel López Puertas

Cited by *JGR: Space Physics* Editors

JGR: Space Physics



Nicole Suzanne Lovenduski

Cited by Tatiana Ilyina

Geophysical Research Letters



Paul Lundgren

Cited by Andrew Newman

Geophysical Research Letters



John MacLennan

Cited by Thorsten Becker

Geochemistry, Geophysics, Geosystems



Andrew R. Mahoney

Cited by Andrey Proshutinsky

JGR: Oceans



Ward Manchester

Cited by Delores Knipp

Space Weather



Gerhard Masselink

Cited by *JGR: Earth Surface* Editors

JGR: Earth Surface



Thorsten Mauritsen

Cited by Jonathan Jiang

Earth and Space Science



Matthew R. Mazloff

Cited by Don Chambers

JGR: Oceans



Brendan T. McCormick

Cited by James Crawford

JGR: Atmospheres



Leo F. McNamara

Cited by Phil Wilkinson

Radio Science



Nadine McQuarrie
Cited by John Geissman
Tectonics



Brian Medeiros
Cited by Robert Pincus
*Journal of Advances in Modeling
Earth Systems (JAMES)*



Mark A. Merrifield
Cited by Leo Oey
JGR: Oceans



Gretchen R. Miller
Cited by Alberto Montanari
Water Resources Research



Kevan Moffett
Cited by Alberto Montanari
Water Resources Research



Annalisa Molini
Cited by Paul D. Williams
Geophysical Research Letters



Stephen Montzka
Cited by Joel Thornton
Geophysical Research Letters



Julia Moriarty
Cited by Robert Hetland
JGR: Oceans



Tsugunobu Nagai
Cited by William Peterson
Geophysical Research Letters



Heidi M. Nepf
Cited by Alberto Montanari
Water Resources Research



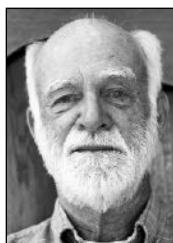
Roseanna Neupauer
Cited by Alberto Montanari
Water Resources Research



Insa Neuweiler
Cited by Alberto Montanari
Water Resources Research



Andre Niemeijer
Cited by Uri ten Brink
JGR: Solid Earth



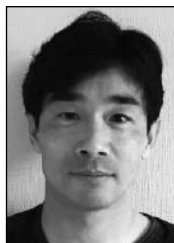
Steve Norton
Cited by Miguel Goni
JGR: Biogeosciences



Wolfgang Nowak
Cited by Alberto Montanari
Water Resources Research



T. Paul O'Brien
Cited by *JGR: Space Physics* Editors
JGR: Space Physics

**Eitarou Oka**

Cited by Meghan Cronin
Geophysical Research Letters

**Friederike Otto**

Cited by Noah Diffenbaugh
Geophysical Research Letters

**Minna Palmroth**

Cited by *JGR: Space Physics* Editors
JGR: Space Physics

**Mark P. Panning**

Cited by Thorsten Becker
Geochemistry, Geophysics, Geosystems

**Athanasios Paschalis**

Cited by Alberto Montanari
Water Resources Research

**Paola Passalacqua**

Cited by Alberto Montanari
Water Resources Research

**Daniele Pedretti**

Cited by Alberto Montanari
Water Resources Research

**Anne Pluymakers**

Cited by Uri ten Brink
JGR: Solid Earth

**Michael P. Poland**

Cited by Andrew Newman
Geophysical Research Letters

**Sally L. Potter-McIntyre**

Cited by Steven Hauck
JGR: Planets

**Yun Qian**

Cited by Zhanqing Li
JGR: Atmospheres

**Vladimir Rakov**

Cited by Steven Ghan
JGR: Atmospheres

**T. S. Ramakrishnan**

Cited by Alberto Montanari
Water Resources Research

**Alan Robock**

Cited by José D. Fuentes
Eos

**Michael Roderick**

Cited by Ruby Leung
JGR: Atmospheres

**Barbara A. Romanowicz**

Cited by Uri ten Brink
JGR: Solid Earth



Daniel Rosenfeld
Cited by Zhanqing Li
JGR: Atmospheres



Charles Rougé
Cited by Alberto Montanari
Water Resources Research



John F. Rudge
Cited by Thorsten Becker
Geochemistry, Geophysics, Geosystems



Audrey Sawyer
Cited by Noah Diffenbaugh
Geophysical Research Letters



Jacob Scheff
Cited by Steven Ghan
JGR: Atmospheres



Erik E. Scherer
Cited by Thorsten Becker
Geochemistry, Geophysics, Geosystems



Brandon Schmandt
Cited by Michael Wyession
Geophysical Research Letters



Christopher H. Scholz
Cited by Uri ten Brink
JGR: Solid Earth



Russell L. Scott
Cited by Ankur Desai
JGR: Biogeosciences



Victor A. Sergeev
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



David R. Shelly
Cited by Michael Wyession
Geophysical Research Letters



Steven Sherwood
Cited by Noah Diffenbaugh
Geophysical Research Letters



Martin Singh
Cited by Paul D. Williams
Geophysical Research Letters



Miriam Sinnhuber
Cited by Ulrike Langematz
JGR: Atmospheres



Giorgio Spada
Cited by Fabio Florindo
Reviews of Geophysics



Hui Su
Cited by Jonathan Jiang
Earth and Space Science



Zhenpeng Su
Cited by Benoit Lavraud
Geophysical Research Letters



Ryan Sullivan
Cited by Joel Thornton
Geophysical Research Letters



Jason D. Surratt
Cited by Lynn Russell
JGR: Atmospheres



Kazue Takahashi
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Yukari N. Takayabu
Cited by Paul D. Williams
Geophysical Research Letters



Toshiro Tanimoto
Cited by Uri ten Brink
JGR: Solid Earth



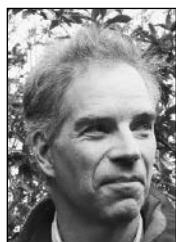
Mary-Louise Timmermans
Cited by Andrey Proshutinsky
JGR: Oceans



Victor Tsai
Cited by Michael Wyssession
Geophysical Research Letters



Bruce T. Tsurutani
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Geert Jan van Oldenborgh
Cited by Chidong Zhang
JGR: Atmospheres



Angelos Vourlidas
Cited by *JGR: Space Physics* Editors
JGR: Space Physics



Yoshihide Wada
Cited by Paul Dirmeyer
Journal of Advances in Modeling Earth Systems (JAMES)



Thomas Wahl
Cited by Don Chambers
JGR: Oceans



Aihui Wang
Cited by Ruby Leung
JGR: Atmospheres



Sam Wilson
Cited by Tatiana Ilyina
Geophysical Research Letters



Paul Withers
Cited by Andrew J. Dombard
Geophysical Research Letters



Brian Yanites
Cited by Nathan Niemi
Tectonics



Chidong Zhang
Cited by Eelco Rohling
Reviews of Geophysics

2015 Cited Referees Not Pictured

Stephen Monismith
Cited by Lisa Beal
Geophysical Research Letters

Natalia P. Perevalova
Cited by *JGR: Space Physics* Editors
JGR: Space Physics

Francesco Serinaldi
Cited by Alberto Montanari
Water Resources Research

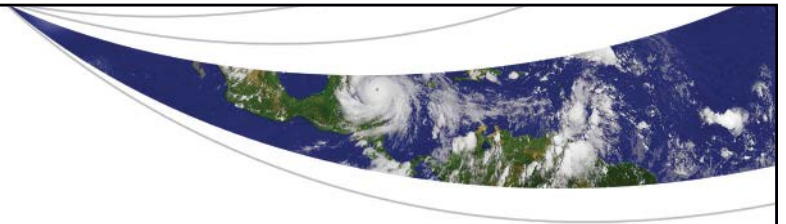
Richard Penney
Cited by Phil Wilkinson
Radio Science

Frank Ryan
Cited by Phil Wilkinson
Radio Science

Kevin Speer
Cited by Lisa Beal
Geophysical Research Letters

Earth's Future

AN OPEN ACCESS AGU JOURNAL



Now Accepting Applications for Natural Hazards Editor of *Earth's Future*

AGU is seeking an editor specializing in natural hazards papers for *Earth's Future*. The ideal candidate should be able to combine specialized knowledge with a broad, transdisciplinary approach. The editor will handle manuscripts from all areas related to natural hazards, including hydrology, atmospheric science, oceanography, solid Earth, and disaster science.

If you would like to be considered for this position, please send your curriculum vitae with a letter of interest via email to pubmatters@agu.org.

 **AGU**. PUBLICATIONS



AGU LEADER

2016 ELECTIONS

**Vote in the upcoming election
and take part in influencing the
direction of AGU.**

- Ensure your AGU membership and section/
focus group affiliations are current in order
to be eligible to vote by **1 August**
- **29 August:** Polls open
- Cast your vote **29 August - 27 September**



elections.agu.org

Streamlining Rapid Tsunami Forecasting



Daniel Zietlow

On 28 October 2012 the Haida Gwaii earthquake (magnitude 7.8) struck off the coast of British Columbia. Tsunami warnings triggered coastal evacuations in Canada, the northern United States, and Hawaii, but no deaths or significant structural damage occurred. Those tsunami warnings were generated by traditional methods that rely on a fault model of the tsunami source. Now *Gusman et al.* suggest that source data may not be necessary for real-time tsunami forecasts.

The researchers compiled Haida Gwaii tsunami data from dozens of ocean bottom seismometers, equipped with pressure gauges, that had been installed offshore of Oregon and California. Spaced 10–50 kilometers apart, these gauges directly sense a passing tsunami wave, providing much denser data than are normally collected for tsunamis. The authors used these data to compare two different forecasting methods.

In the first method, the scientists used pressure gauge data and a fault model to estimate the locations of fault slip that caused the tsunami. This allowed them to calculate sea surface displacement

On the deck of the R/V Oceanus, engineers from Woods Hole Oceanographic Institution decommission an ocean bottom seismometer and differential pressure gauge deployed as part of the Cascadia Initiative to study the Juan De Fuca and Gorda plates offshore of Oregon and Washington. Data from the seafloor pressure gauges were used in a tsunami study by Gusman et al.

and simulate tsunami size and timing. The second method ignored the earthquake source. Instead, pressure gauge data continuously fed and refined a wave field model that predicted the tsunami's movement.

When the researchers compared the simulations with observations of the Haida Gwaii tsunami, they found that both methods accurately forecast tsunami timing and amplitude, with a warning time of 30 minutes or longer. The success of the second method suggests that with a dense enough sensor array, real-time tsunami predictions do not require a fault model. (*Geophysical Research Letters*, doi:10.1002/2016GL068368, 2016) —**Sarah Stanley, Freelance Writer**

Researchers Attribute Human Influence on Climate Back to 1930s

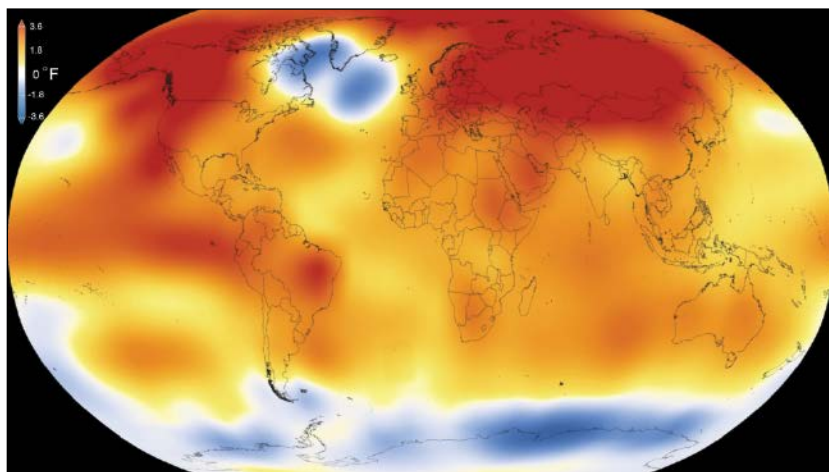
In recent years, as the effects of climate change have become more apparent, scientists have attempted to determine whether specific extreme weather events, such as heat waves, droughts, and cold spells, are more likely to occur. Researchers have also tried to figure out whether past extreme events can be attributed to human influences on global climate.

Here *King et al.* examined past hot years and seasons that exceeded the range of natural variability, going back to 1900 or as far back as observational data allowed. They used a climate model to compare the likelihood of these events occurring when looking at only natural climate influences and when including both natural and human influences.

Examining extreme heat events in five different regions—central England, central Europe, central United States, East Asia, and Australia—the researchers found that humans have likely caused the 16 most recent record-breaking hot years experienced on Earth, up to 2014.

They found that this influence on global climate goes back as far as 1937, an effect that has been masked until recent decades by the wide use of industrial aerosols, which have a cooling effect on temperatures.

According to the study, aerosol concentrations in central England, central United States, central Europe, and East Asia caused cooling periods during the 1970s that delayed the emergence of a clear



This visualization illustrates Earth's long-term warming trend, showing temperature changes from 1880 to 2015 as a rolling 5-year average. Orange colors represent temperatures that are warmer than the 1951–1980 baseline average, and blues represent temperatures cooler than the baseline. A new study shows that humans have likely triggered the past 16 record-breaking hot years experienced on Earth.

human influence on climate. The researchers concluded that without human-induced climate change, recent hot summers and years would not have occurred. (*Geophysical Research Letters*, doi:10.1002/2015GL067448, 2016) —Lauren Lipuma, Contributing Writer

The Role of Water in Earth's Tectonic Plumbing Systems

When tectonic plates collide and separate, fractures spread across Earth's crust. Beneath the planet's surface these fractures act like a natural plumbing system, carrying water down from the surface.

The hydrogeological characteristics of these fault zones—the properties that affect how groundwater moves around the fault—are hugely important for faulting processes and stability. However, the hydrogeological properties of faults are difficult to measure and remain somewhat poorly defined.

Fortunately, well systems can provide a window into the unseen hydrological processes going on underground. Tidal forces influence the hydraulic head of aquifers—a measure of water pressure and elevation in groundwater that determines the direction of water flow—which, in turn, influences the height of water in wells. Here *Xue et al.* take advantage of this relationship, measuring well water responses to Earth's tides to

examine and assess the hydrogeologic properties of the San Andreas Fault.

The researchers looked at four monitoring wells in a quartz gabbro quarry in Aromas, Calif., located at varying distances from the San Andreas Fault. Between April 2014 and July 2015 the team used pressure sensors to measure the water level in each well every 10 minutes. The sensors picked up both water and barometric pressure; to account for barometric pressure separately, the researchers placed a sensor inside a well above the water level.

The water level response to tidal forcing within wells is a product of the permeability of the crust material around a well and its storativity—the amount of water that is released from an aquifer as the hydraulic head declines. The researchers found that the two wells closest to the fault were roughly 10 times more permeable than the two wells farthest away. The specific storage capacity of the closer wells was also larger. The observed storage structure

is novel. Taken together, however, the permeability and storativity of all four wells result in a relative uniform hydraulic diffusivity measure of 0.01 square meter per second. The uniform diffusivity structure suggests that the permeability contrast might not efficiently trap fluids near faults during the interseismic periods. The team also examined data from a broadband seismic station to assess the effect of earthquakes on the permeability of wells' surrounding formation. They found that quakes increased the permeability of some wells by as much as 160%.

The measures of specific storage are particularly relevant for understanding fault mechanics, as storage capacity can influence the fault's response to stress. The study shows that well water response to tidal forcing can be a valuable proxy for hydrogeological structures beneath Earth's surface. (*Geochemistry, Geophysics, Geosystems*, doi:10.1002/2015GC006167, 2016) —Kate Wheeling, Freelance Writer

Martian Carbonates Spotted by the Orbiter

The search for life on Mars has been fueled by findings that suggest the Red Planet may have once been a wet one, with ancient lakes, rivers, and oceans flowing over its surface. Where there is water, there can be life, if Earth is any example. Scientists believe that if water did once flow on the surface of Mars, the planet's bedrock should be full of carbonates—minerals that would have formed when paleoatmospheric carbon dioxide was trapped in ancient surface waters. Such minerals could provide further evidence that Mars was once host to habitable, watery environments, but researchers have struggled to find physical evidence for a carbonate-rich bedrock.

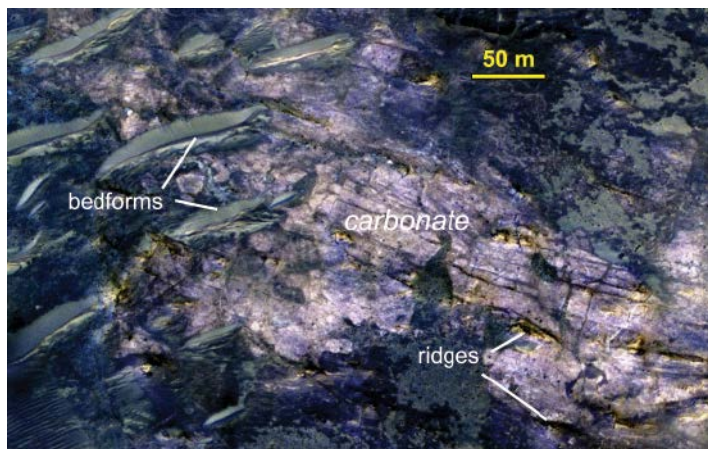
Now Wray *et al.* provide new evidence for the existence of buried deposits of iron- and calcium-rich Martian carbonates. The researchers identified carbonates on the planet with the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) aboard the Mars Reconnaissance Orbiter. The tool picks up on the unique spectral signatures carbonate ions give off during vibrational transitions. The team paired CRISM data with images from the High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX) on the orbiter and the Mars Orbiter Laser Altimeter (MOLA) on the Mars Global Surveyor to gain insights into the geologic features associated with carbonate-bearing rocks.

The researchers detected iron- and calcium-rich carbonate-bearing rocks in the Huygens basin, a basin greater than 450 kilometers wide that is rimmed with impact craters and troughs that expose ancient, sub-surface materials. The widespread detection of carbonate-bearing rocks in the basin suggests that at least regionally, conditions were once suitable for carbonate formation.

The strong carbonate signals in impact craters such as the Lucaya crater suggest that the minerals may have been previously buried as deep as 5 kilometers below the surface in ancient rock more than 3.8 billion years old. Thus they represent a window into a time when the climate on Mars was very different than today. The depth and age of these rocks may partially explain why researchers failed to find large areas of carbonate-loaded bedrock in the past. Without a plate tectonic system like that of Earth to push buried materials to

the surface, impacts may be one of the only ways to excavate deposits of carbonate-rich rocks.

The global distribution of Martian carbonates has yet to be resolved. Still, the authors note, the ancient carbonates could serve as a point of comparison for organics found on Mars to identify biosignatures of ancient life on the Red Planet. (*Journal of Geophysical Research: Planets*, doi:10.1002/2015JE004972, 2016) —Kate Wheeling, Freelance Writer



Aeolian bedforms overlie ancient layered, ridged carbonate-rich outcrop exposed in the central pit of Lucaya crater, northwestern Huygens basin, Mars. The image was taken by the High Resolution Imaging Science Experiment (HiRISE) instrument aboard the Mars Reconnaissance Orbiter.

Improving the Identification of Extreme U.S. Precipitation Trends

Because extreme precipitation events have the potential to cause severe damage and economic loss, many studies have searched for trends in heavy precipitation across the United States. However, these previous analyses either have failed to include common regional information that could reduce uncertainty and improve trend detection or have focused only on small and homogeneous regions.

To better identify significant spatial trends—especially across larger areas—Sun and Lall have developed a new statistical “clustering” model that analyzes multiple sources of data to identify statistically homogeneous areas, group these data together, and

share chosen model parameters within each group. Because this new approach greatly reduces estimation uncertainties, it improves the detection of statistically significant trends at regional and local scales.

The team used this model to search for trends in the maximum daily precipitation across the United States each year from 1941 to 2010. After analyzing data collected from 90 HadEX2 weather observation stations, the researchers identified statistically significant trends of increasing precipitation in the Midwest, the Northeast, and the northern reaches of the Southeast. Although these trends are consistent with the results of a number of other studies, the new model

is much better at discerning them, the authors report. In this analysis, all 14 stations in the Midwest displayed a significant statistical trend, compared with only four stations when a previous single-site analysis is used.

This new approach results in predictions that are more precise, including for extreme events. The authors argue that the reduction in model uncertainty is especially important for engineering design standards and for improving the seasonal forecasting of rare events, including those related to the El Niño–Southern Oscillation. (*Geophysical Research Letters*, doi:10.1002/2015GL066483, 2015) —Terri Cook, Freelance Writer

AGU's Career Center is the main resource for recruitment advertising.

All Positions Available and additional job postings can be viewed at <https://eos.org/jobs-support>.

AGU offers printed recruitment advertising in *Eos* to reinforce your online job visibility and your brand.

Visit employers.agu.org to view all of the packages available for recruitment advertising.

SIMPLE TO RECRUIT

- online packages to access our Career Center audience
- 30-day and 60-day options available
- prices range \$475–\$1,215

CHALLENGING TO RECRUIT

- online and print packages to access the wider AGU community
- 30-day and 60-day options available
- prices range \$795–\$2,691

DIFFICULT TO RECRUIT

- our most powerful packages for maximum multimedia exposure to the AGU community
- 30-day and 60-day options available
- prices range \$2,245–\$5,841

FREE TO RECRUIT

- packages apply only to student and graduate student roles and all bookings are subject to AGU approval
- eligible roles include: student fellowships, internships, assistantships, and scholarships

- *Eos* is published semi-monthly on the 1st and 15th of every month. Deadlines for ads in each issue are published at <http://sites.agu.org/media-kits/eos-advertising-deadlines/>.
- *Eos* accepts employment and open position advertisements from governments, individuals, organizations, and academic institutions. We reserve the right to accept or reject ads at our discretion.
- *Eos* is not responsible for typographical errors.

* Print-only recruitment ads will only be allowed for those whose requirements include that positions must be advertised in a printed/paper medium.

ENVIRONMENTAL SCIENCE

Faculty Positions in Geosciences and in Environmental Sciences

The Department of Earth and Planetary Sciences at Johns Hopkins University invites applications for multiple tenure-track or tenured faculty positions. The positions can be filled at the Assistant, Associate, or Full Professor level, starting as early as Fall 2016. The successful candidates are expected to develop internationally recognized and externally funded research programs, to help develop and participate in undergraduate and graduate teaching, and to supervise graduate student research. In the case of an appointment with tenure, the candidate must already be internationally recognized and have a demonstrated record of external research funding. A Ph.D. is required in the Earth Sciences or a related natural sciences discipline; post-doctoral experience is desirable. Applicants are sought for two focus areas:

Geosciences including low-temperature geochemistry and studies of the early Earth, cosmochemistry, geophysics and geodynamics, volcanology and igneous petrology. We are particularly interested in candidates whose research has synergies with our recent hires with expertise in sedimentary, metamorphic and tectonic processes, planetary geology, and planetary atmospheres.

Environmental Sciences including: natural resources (including water, metals, soils, and energy), ecology, critical zone science, marine sciences, cryospheric sciences, geomorphology, landscape hydrology, environmental change, air pollution, and, biogeochemistry. We are particularly interested in candidates whose research has

synergies with our program in Global Environmental Change and Sustainability.

Opportunities exist for the successful candidate to forge research and teaching ties with other parts of the Johns Hopkins community that are active in the earth and environmental sciences, and sustainability. They include multiple engineering departments, Environmental Health Sciences at the School of Public Health, the Applied Physics Laboratory, and the cross-departmental Environment, Energy, Sustainability, and Health Institute. There are excellent opportunities for additional collaborations within the Baltimore-Washington region, including with the Carnegie Institution, the Smithsonian Institution, the U.S. Geological Survey, the University of Maryland, and NASA Goddard Space Flight Center.

Applications must be submitted electronically using Interfolio <http://apply.interfolio.com/34960>, should indicate the relevant focus area and must include a cover letter, a curriculum vitae, statements of research and teaching interests, and the names and complete contact information of at least three references. Questions concerning submission of application materials should be directed to Kristen Heisey (kgaines@jhu.edu). Other requests for information may be directed to Professor Sverjensky, Geosciences, Search Committee Chair (sver@jhu.edu) and/or Professor Waugh, Environmental Sciences Search Committee Chair (Waugh@jhu.edu). Review of the applications will begin immediately and will continue until the positions are filled. Applications received by 30 June, 2016 will receive full consideration.

The Collaborative Research Center **TRR 181 "Energy transfers in Atmosphere and Ocean"** invites applications for **32 PhD and 14 Research Associate positions**. TRR 181 is a collaborative between the German Universities Hamburg and Bremen and further participating institutions funded by DFG for initially four years. Phys. oceanographers, meteorologists and applied mathematicians work together in the project to understand the energy transfers between the different dynamical regimes - smallscale turbulence, internal gravity waves and geostrophically balanced motion in both atmosphere and ocean to develop, to test, and to implement new and consistent parameterisations in models, and to develop mathematical and numerical methods featuring consistent energetics. Requirements: **MSc or Phd degree** in physical oceanography, meteorology, applied mathematics or a related field, high motivation to work in an interdisciplinary environment. The Collaborative Research Center TRR 181 aims to increase the number of women in research and teaching in this field and explicitly encourages women to apply. **The openings may be situated at any of the participating institutions.** The earliest start of the positions is **1. July 2016**. Applications, including a letter of motivation and CV (pdf, one document, not more than 8 MB) should be sent to trr181.cen@uni-hamburg.de. More information can be found on the TRR project website <http://www.trr-energytransfers.de>.

Johns Hopkins University is committed to active recruitment of a diverse faculty and student body. The University is an Affirmative Action/Equal Opportunity Employer of women, minorities, protected veterans and individuals with disabilities and encourages applications from these and other protected group members. Consistent with the University's goals of achieving excellence in all areas, we will assess the comprehensive qualifications of each applicant.

HYDROLOGY

Faculty Cluster Hire in WATER.

The University of California Irvine announces an interdisciplinary cluster hire of four faculty members to increase its capacity and world leadership in tackling the grand challenges related to water in urbanized environments, including water-related environmental and food security issues. Southern California is a mosaic of cities and open spaces whose history and future are inextricably tied to water, and whose experiences with water are paralleled by coastal metropolitan areas around the world facing population growth, development pressure, demands for ecosystem protection, and water scarcity. The cluster hire will build on UC Irvine's existing strengths in

urban planning, public policy, hydrology, water resources, ecosystems, earth system science, and climate change and will be uniquely positioned and supported to grow new multidisciplinary collaborations across campus emphasizing new paradigms of sustainability and ecosystem resilience for metropolitan areas. We are seeking candidates whose research involves field studies, modeling and theory and, based on academic preparation and research interests, would fit into one of the following four Departmental positions:

Water resources: Tenured Associate or Full Professor in the Department of Civil and Environmental Engineering (<http://engineering.uci.edu/dept/cee>) with particular interest in candidates who integrate field studies, modeling and theory to advance understanding of water cycle dynamics in coupled human-natural systems.

Water and ecosystems: Tenured Associate Professor in the Department of Ecology and Evolutionary Biology (<http://ecoevo.bio.uci.edu/>) with particular interest in candidates who pursue predictive understanding of ecosystem processes and their response to climate and human pressures via theoretical, field work, and modeling approaches.

Water and food security: Tenure-track Assistant Professor in the Department of Earth System Science (<http://www.ess.uci.edu>) with particular interest in candidates with expertise and interest in understanding water at the intersection of optimizing food production and environmental sustainability in water-scarce environments.

Water and resource economics: Tenured Associate or Full Professor in the Department of Planning, Policy and Design (<http://ppd.soceco.uci.edu/>) with particular interest in candidates with expertise and interest in the area of environmental economics, natural capital, valuation of ecosystem services, urban planning, and public policy.

UCI has an exceptional array of field sites, open-space preserves, partner relationships, and research facilities that are strategically aligned in the context of geography, climatology, economic and social structures of southern California. Bringing faculty and students together around the theme of WATER offers a unique opportunity to create exceptional research capacity at UCI for addressing challenges at the water-food-energy nexus under increasing climate and human pressures. Applicants are encouraged to visit Departmental websites (shown

above) to learn more about research strengths and programs. With this cluster hiring initiative, UCI aspires to identify exceptionally talented candidates who share our vision and will increase our capacity for world leadership.

Applicants are expected to have advanced degrees and publication records commensurate with appointment levels in the department of interest. Successful candidates will be expected to develop externally funded research programs, engage in both undergraduate and graduate education, and contribute their leadership and innovative thinking towards global prominence in water, cities, and the environment. Teaching opportunities will vary by Department and teaching qualifications will be a consideration for fit with the respective unit. Successful candidates will also be expected to contribute towards a campus-wide initiative to create more field-based (off-campus) student learning opportunities with the goal of increasing the number of students (especially underrepresented minority students) pursuing graduate degrees in water-related programs.

Applications should include a cover letter, a description of research interests illuminating potential to support the goals of the cluster hire, a

PLACE YOUR AD HERE

Visit Careers.agu.org to learn more about employment advertising with AGU

description of teaching interests including ability to contribute to Departmental and interdisciplinary programs, a curriculum vitae, a statement describing commitment to diversity, and the names of at least four references. (References would not be contacted until the later stages of consideration, after consultation.)

To be considered for one of the four available positions, apply electronically at:

Department of Civil and Environmental Engineering: <https://recruit.ap.uci.edu/apply/JPF03389>

Department of Ecology and Evolutionary Biology: <https://recruit.ap.uci.edu/apply/JPF03408>

Department of Earth System Science: <https://recruit.ap.uci.edu/apply/JPF03396>

Department of Planning, Policy and Design: <https://recruit.ap.uci.edu/apply/JPF03377>

The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

SPACE PHYSICS

Postdoc – Ionospheric radio occultations at Saturn, Titan, and Mars

The Center for Space Physics at Boston University invites applications for a postdoctoral researcher position supervised by Professor Paul Withers. The research will involve the analysis of radio occultation observations of the ionospheres of Saturn, Titan, and Mars. Candidates should possess a PhD degree in a relevant field. Experience conducting research on planetary ionospheres is desirable. The salary offered will be competitive and commensurate with experience. Funding is available for two years with the possibility of extension. The appointment is expected to begin as soon as possible after 1 September 2016. Please contact Paul Withers (withers@bu.edu) for further information.

Applications should be sent by email to Paul Withers (withers@bu.edu). The application should be submitted in PDF format and contain a curriculum vitae, statement of research interests, and contact information for three referees. Review of applications will begin on 15 July 2016. Women and underrepresented minorities are particularly encouraged to apply. Boston University is an equal opportunity/affirmative action employer.

AGU Career Center

Tools to Help You Manage Your Career

With the AGU Career Center you can:

- Search and respond to job listings
- Participate in Career Advice Webinars
- Update your resume to manage and track your career accomplishments
- Access information from past Career Advice Workshops and Webinars
- Access resources to help manage your current and future career



careers.agu.org

NASA Marshall Space Flight Center Earth Science Office

The Earth Science Office at Marshall Space Flight Center is soliciting statements of interest for full-time PhD level scientist positions for early-and mid-career positions in the following areas:

Hydrologic Processes

Atmospheric Remote Sensing

Radio Frequency Engineer for Microwave Remote Sensing

Climate Science

Applications of Synthetic Aperture Radar

Visit our website (http://weather.msfc.nasa.gov/esohome/MSFC_ESO_rfi.pdf) for full descriptions. Interested candidates may respond to this Request for Information (RFI) by submitting a cover letter, curriculum vitae, and statement of research interests in a single pdf file to paul.f.tatum@nasa.gov. This submission will not replace the formal application process for the anticipated positions when/if they are advertised on USAJOBS (<https://www.usajobs.gov>).

Postcards from the Field

Dear Everyone,

We are offshore waiting for calmer waters before landing at the settlement of Edinburgh of the Seven Seas on Tristan da Cunha in the middle of the South Atlantic Ocean. After sailing in rough seas from Cape Town for 5 days, we are eager to have some solid ground underneath our feet. The new tide gauge and permanent Global Navigation Satellite System station we bring will provide important observations for sea level studies.

Wish you were here to meet the most welcoming Tristanians with us.

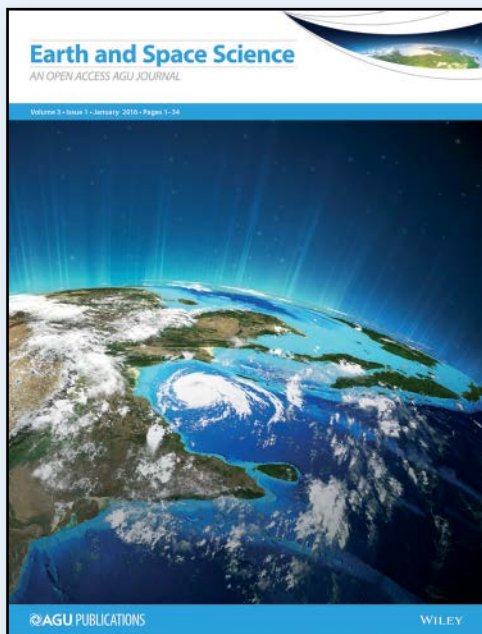
Norman Teferle, University of Luxembourg

View more postcards at

<http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field>.

Earth and Space Science

AN OPEN ACCESS AGU JOURNAL



Earth and Space Science (ESS) welcomes high-quality original research papers spanning all of the Earth, planetary, and space sciences, including related fields in environmental science, geo- and space-engineering, and biogeochemistry. *ESS* particularly welcomes papers presenting and interpreting key data sets and observations that are critical, singularly or in aggregate, for a broader scientific understanding of the Earth and its environment, as well as our solar system and beyond, or papers that add to the understanding of such observations (e.g., methodology, theory, mapping, and modeling). In particular, *ESS* is seeking papers that highlight methods, instruments, sensors, data and algorithms that contribute to the Earth and space sciences. The papers must highlight the application of these methods to specific data.



Editor in Chief

John A. Orcutt, Scripps Institution of Oceanography, University of California, San Diego, jorcutt@ucsd.edu

Editors

Andrea Donnellan, NASA Jet Propulsion Laboratory, California Institute of Technology, andrea.donnellan@jpl.nasa.gov

Jonathan H. Jiang, NASA Jet Propulsion Laboratory, California Institute of Technology, jonathan.h.jiang@jpl.nasa.gov

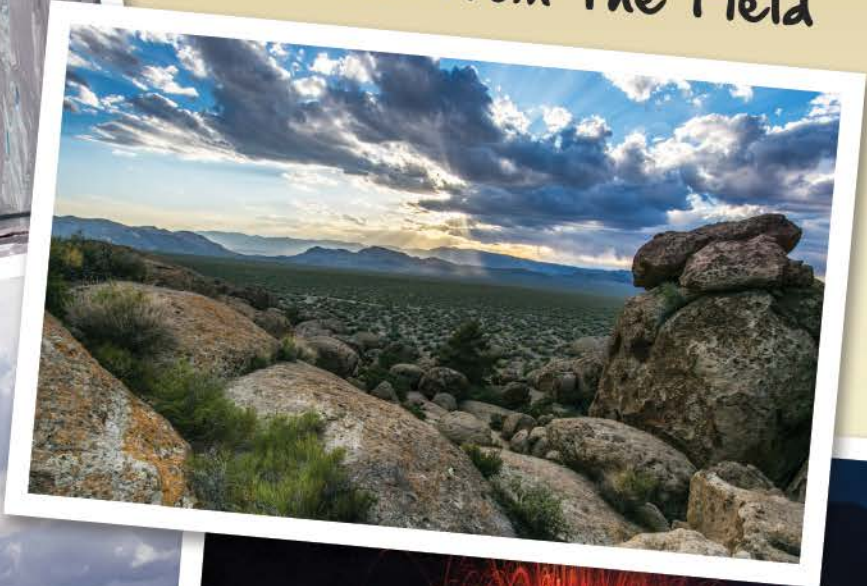
Benoit Pirene, University of Victoria, bpirene@uvic.ca

Frank Vernon, University of California, San Diego, flvernon@ucsd.edu

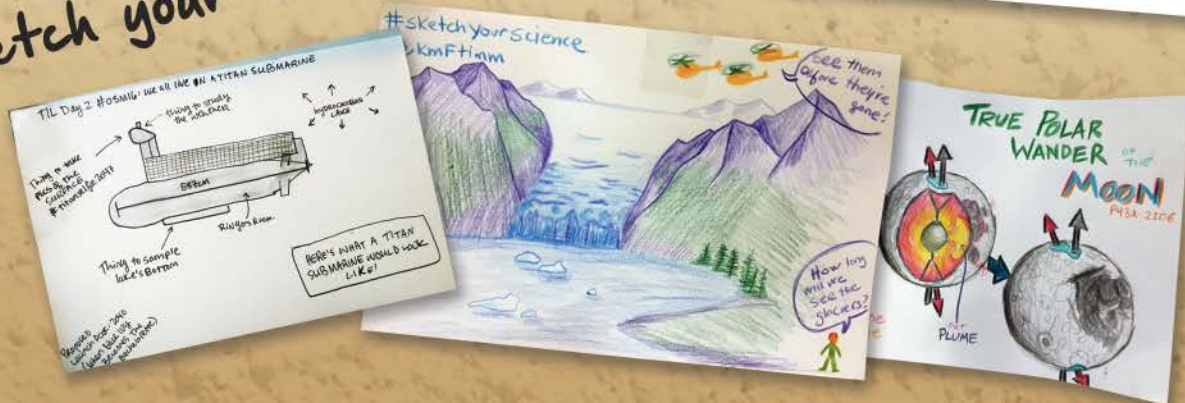
earthspacescience@agu.org • earthspacescience.agu.org

Two Great Ways to Share Your Science with AGU

Postcards from the Field



Sketch your Science



View postcards and sketches as well as submission guidelines at
americangeophysicalunion.tumblr.com